

CHILDREN OF THE REVOLUTION
The age of genetically engineered people is here

NewScientist

WEEKLY May 2 - 8, 2015

SPECIAL ISSUE

THE HUMAN UNIVERSE

Does consciousness create reality?

Was the universe made for us?

Can we understand everything?

Do aliens know we're here?

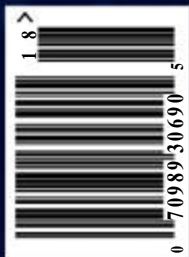
Could we destroy the universe?

What will our lasting legacy be?

Should we colonize space?

Will we become gods?

No3019
US\$5.95
CAN\$5.95



PREDATORS VS ALIENS

Earth's weird first life
was eaten alive

IN YOUR DREAMS

How sleeping brains
make the bizarre normal

AFTERSHOCK

Nepal monsoon threatens
further quake chaos

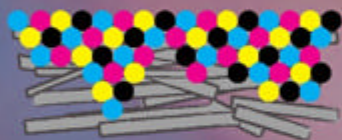
Science and technology news www.newscientist.com US jobs in science

ALL PAPER IS NOT CREATED EQUAL.

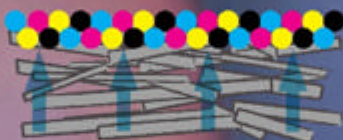
Especially in business, looking good on paper really matters. ColorLok® Technology gives paper more vivid colours, bolder blacks, and faster drying times.* So make a strong impression by choosing paper with the ColorLok logo. [Learn more at colorlok.com](http://colorlok.com)

THE SCIENCE OF WOWING YOUR CUSTOMERS

ColorLok Technology turns everyday office paper into your canvas for eye-popping imagery and incredibly professional presentations. How? By injecting additives during the paper-making process that enable the paper to "lock" pigments at the surface. Without this technology, paper acts more like a sponge, absorbing black and colour pigments deep into the fibres of the paper and away from the surface.



Without ColorLok Technology, pigment sinks deep into the paper's fibres. Black appears duller and colours less vibrant.



When you print on paper with ColorLok Technology, the additives within the paper react with the pigments, keeping colour near the surface for bold, vivid results.

A NEW LOOK FOR ECO-FRIENDLY PAPER

Even recyclable paper looks better than ever, because ColorLok Technology creates a shield between the surface and subsurface fibres. Printouts on recycled paper can now retain a brighter, richer appearance, so you can be eco-friendly without compromising quality. What's more, paper with ColorLok Technology is actually easier to recycle. So yes, you can look good and do good.

© 2015 Hewlett-Packard Development Company, L.P.
The information contained herein is subject to change without notice.
*Independent testing by SpencerLab Digital Color Laboratory, commissioned by HP. The full October 2009 report, "Print Quality Analyses - ColorLok Media Evaluation: AIO Printers: Brother MFC-5490CN, Canon PIXMA MX860 & MX7600, Epson WorkForce 600, HP Officejet 6500 and Officejet Pro 8500," is available for download at spencerlab.com



VIVID COLOURS

Richer, brighter
images and graphics
on all your printers



BOLDER BLACKS

Means crisper, sharper
text and lines than with
standard paper



FASTER DRYING

Less smear and faster
handling compared
to papers without
ColorLok Technology



ECO-FRIENDLY

Easier to recycle,
with results that
don't look dull



CONSISTENCY

Consistent and reliable
printing regardless of
which machine is used





OLYMPUS

Your Vision. Our Future

Olympus Medical Systems

A new perspective.

What has continued to motivate us over the years? Outstanding innovation that generates new perspectives and new possibilities. In the early detection of intestinal cancer, Olympus endoscopes help doctors perform colonoscopy more gently and effectively: the very latest medical technology honed by the visionary power and expertise of a world market leader.

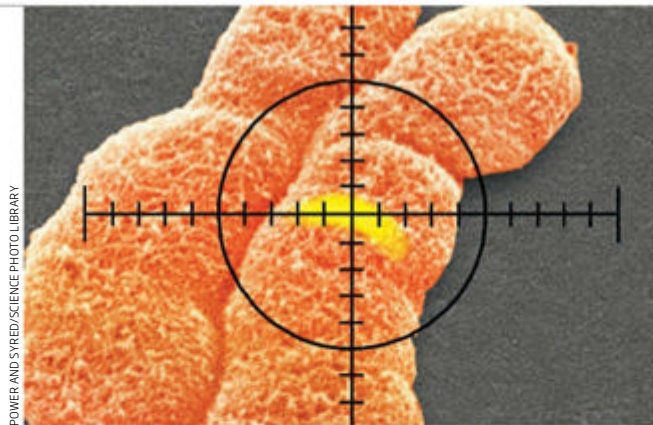
Discover more: www.olympus.co.uk

News

8

Gene editing in embryos begins

Welcome to the age of genetically engineered people



POWER AND SYRED/SCIENCE PHOTO LIBRARY

On the cover

30

Human universe

We're masters of Earth, but what about our place in the cosmos?

Cover image
Sam Chivers

- 8 Children of revolution**
The age of genetically engineered people is here
- 12 Predators vs aliens**
Earth's weird first life was eaten alive
- 14 In your dreams**
How sleeping brains make the bizarre normal
- 6 Aftershock**
Nepal monsoon threatens further quake chaos

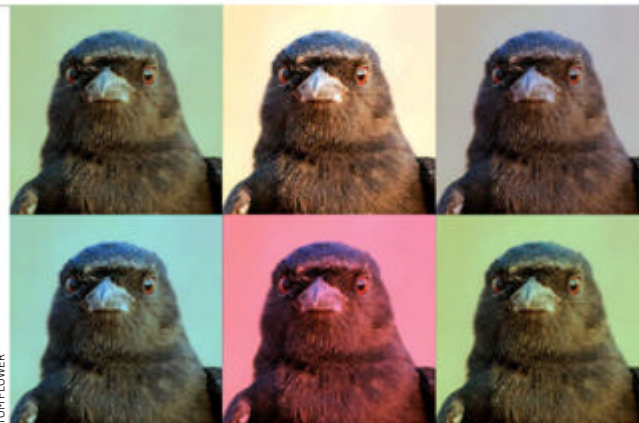


Features

40

Copy birds

Being a convincing mimic can be a matter of life and death



TOM FLOWER

Coming next week...

The next plague

Ebola was a near miss. Is there worse to come?

Rosetta, are you better?

Awaiting the comet mission's second coming

Leader

- 5** The universe is ours. We asked the experts what we should do with it

News

- 6 UPFRONT**
Nepal quake's continuing threat. Bird flu hits US farms. World's first malaria vaccine. UK political parties accused of greenwashing
- 8 THIS WEEK**
How it feels to be invisible. Mars camera goes to Iceland. Milky Way had a gentle past. First predators caused a mass extinction. Microbes worsen climate change. Antarctic aquifers may harbour life. Sleeping brains make the bizarre normal

IN BRIEF

Mosaic dinosaur discovered. Melt DNA to tell twins apart. Effect of tinnitus on the brain

Technology

- 20** Data-mining helps politicians scramble for votes. How to enforce your no drone zone

Aperture

- 24** If our planet had a brain it might look like this

Opinion

- 26 Vote X** Jennifer Rohn on post-election fears
- 26 Dream on** Sexism in science is over? Not yet, says Lisa Grossman
- 27 One minute with... Peter Neufeld** Why I think forensic hair analysis is badly flawed
- 28 Rocket man** Tragedy won't stop Virgin Galactic's David Mackay flying spaceplanes

Features

- 30 The human universe** (see above left)
Was the universe made for us?
Does consciousness create reality?
Can we understand everything?
Could we destroy the universe?
Does the cosmos know we're here?
Could we colonise space?
Can we engineer the universe?
Could we become gods?
- 40 Copy birds** (see left)

CultureLab

- 45 One voice** Why science speaks English
- 46 DNA's hero** Marshall Nirenberg, the mystery

Regulars

- 54 LETTERS** Science involves belief, not faith
- 56 FEEDBACK** Alien signals from a microwave
- 57 THE LAST WORD** Angle of dangle

#MakeThingsBetter
total.uk

COMMITTED TO NATURAL GAS

Total is making substantial investments in the cleanest fossil fuel



TOTAL

COMMITTED TO BETTER ENERGY

NewScientist

LOCATIONS

USA
225 Wyman Street,
Waltham, MA 02451
Please direct telephone enquiries to
our UK office +44 (0) 20 7611 1200

UK
110 High Holborn,
London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

Australia
Tower 2, 475 Victoria Avenue,
Chatswood, NSW 2067
Tel +61 2 9422 8559
Fax +61 2 9422 8552

SUBSCRIPTION SERVICE

For our latest subscription offers, visit
newsscientist.com/subscribe

Customer and subscription services are
also available by:

Telephone 1-888-822-3242
Email subscribe@newsscientist.com
Web newsscientist.com/subscribe
Mail New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953 USA

One year subscription (51 issues) \$154

CONTACTS

Contact us
newsscientist.com/contact

Who's who
newsscientist.com/people

General & media enquiries
enquiries@newsscientist.com

Editorial
Tel 781 734 8770
news@newsscientist.com
features@newsscientist.com
opinion@newsscientist.com

Picture desk
Tel +44 (0) 20 7611 1268

Display advertising
Tel 781 734 8770
displaysales@newsscientist.com

Recruitment advertising
Tel 781 734 8770
nssales@newsscientist.com

Newsstand
Tel 212 237 7987
Distributed by Time/Warner Retail
Sales and Marketing, 260 Cherry-Hill
Road, Parsippany, NJ 07054

Syndication
Tribune Content Agency
Tel 800 637 4082

© 2015 Reed Business
Information Ltd, England.

New Scientist ISSN 0262 4079 is
published weekly except for the last
week in December by Reed Business
Information Ltd, England.

New Scientist at Reed Business
Information, c/o Schnell Publishing Co.
Inc., 225 Wyman Street, Waltham,
MA 02451.

Periodicals postage paid at
Boston, MA and other mailing offices.

Postmaster: Send address changes to
New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a
newspaper and printed in USA by Fry
Communications Inc, Mechanicsburg,
PA 17055



SANCHEZ

The universe is ours

We are the most powerful species in the known universe. What responsibilities come with such power? We asked the experts

"WE COULD be the universe's sole repository of wisdom, scientific insight and technology. Threats to our future are threats to the existence of self-awareness. That ups the ante: we have a responsibility to preserve life on Earth and our own civilisation. We have powers no other species has had before, we're changing the world, but as yet not in any sustainable way: it's random and unthought-out."

David Grinspoon
Planetary Science Institute
Tucson, Arizona

"We've no grounds for assuming that novel human-induced catastrophes are improbable. Indeed, we have zero grounds for confidence that we can survive the worst that future technologies could bring in their wake. Our planet, though tiny, could be cosmically important. And the mission of the first interstellar voyagers from Earth could resonate through the entire galaxy – and perhaps beyond."

Martin Rees
UK Astronomer Royal

"There's a big difference between having one successful civilisation and having none. If you want us

to eventually colonise the stars, we need to minimise the catastrophic events that could disrupt civilisation now: getting a reasonable response to climate change, limiting nuclear weapons and improving surveillance for pandemics over resourcing space programmes. We must make sure nothing disrupts civilisation."

Nick Beckstead
Formerly of the Future of Humanity
Institute, University of Oxford

"Unlike any other organism on the planet, we have foresight, we understand what's happening, and we have science and technology. The pieces are there, we just have to realise what we've got to do. The most important thing is to see Earth as a very, very extraordinary place that needs guardians. That's a role we should take for ourselves – in a way, you could say we'd be looking after the entire universe."

David Waltham
Geophysicist and
author of *Lucky Planet*

"While it's tempting to anthropomorphise the universe as something to which we owe good behaviour, I suspect such fealty is merely a way to chastise

ourselves for the perceived sins of contemporary society. The cosmos is three times the age of our planet. It has workings and, I'm sure, intelligence of types we are incapable of imagining. The crises faced by humanity today are important to us, but they will eventually prove no more significant than a thin bed of sediment in the deep stratigraphy of the universe."

Seth Shostak
Director of the Center for SETI
Research, Mountain View, California

"We know precious little about our place in the universe, except for one thing: we, and any existing cohort of civilisations, will appear as "first born" to anyone living in our universe a 100 billion years from now. So, in the sense of timing, our place in the universe is special. And we have potential, like children: free of responsibilities and growing up to see where life takes us. We might grow up and write the early history of the universe – or not."

Dimitar D. Sasselov
Astronomer and director of the
Harvard Origins of Life Initiative

Our special report on humanity's place
in the universe begins on page 30



Now stop the landslides

WITH Nepal's prime minister warning that the death toll from Saturday's earthquake could reach 10,000, the current focus is on rescuing people. But over the coming weeks, preventing landslides could stop thousands more lives being lost.

Following large earthquakes, landslides can be as deadly as the quake itself, causing up to half of the casualties.

Shake maps have enabled scientists to estimate landslide probability across the region, giving an indication of the areas most at risk. One of the biggest concerns is temporary dams that can build up when a landslide blocks a river.

"Once the monsoon rains arrive in mid to late June, these dams will fill very quickly and fail within a matter of days, flooding the valley below," says

Alex Densmore, a landslide expert at Durham University, UK.

In the weeks following the Sichuan earthquake in China in 2008, the Chinese were very efficient at getting diggers to the landslides and removing the worst dams, thereby avoiding further catastrophe. "I'm not sure if Nepal has the capacity to do this, but our first priority will be to pass on information about these temporary dams to our colleagues in Nepal," says Densmore. "We certainly expect another pulse of landslides when the monsoon arrives in June."

Geologists will also be trying to anticipate how the landscape is likely to change. Right now, wide open river valleys far away from steep slopes may look like sensible places to resettle people, but these may be buried once the monsoon rains wash

excess sediment down from the hills. "After the Sichuan earthquake, some of the most productive farmland was buried under metres of sand, making the valleys uninhabitable, and survivors were moved to new towns," says Densmore.

Nepal remains at risk of another major quake. "Early calculations suggest that Saturday's magnitude 7.8 earthquake was probably not big enough to rupture all the way to the surface, so there is still likely to be more strain stored," says Laurent Bollinger of the French Alternative Energies and Atomic Energy Commission. "We should probably expect another big earthquake to the west and south of this one in the coming decades." Bollinger's team believes the quake was primed by Nepal's last major quake, in 1934.

Mercury nosedive

DON'T shoot the Messenger – it's already on a collision course with Mercury. NASA's Messenger space probe, which has been orbiting the planet for over four years, has run out of fuel and is expected to hit the surface on 30 April.

The spacecraft actually burned the last of its fuel in January, but in April, NASA engineers squeezed out a little extra thrust by venting on-board helium gas, which was used to pressurise the fuel. This gave the craft more time in orbit, with a final boost last Friday.

With nothing left to fight gravity, Messenger will crash into Mercury's surface at over 14,000

"With nothing left to fight gravity, Messenger will crash into Mercury at 14,000 kilometres an hour"

kilometres an hour, creating a crater 16 kilometres across.

Examining the fresh crater could provide data on how space weathering affects Mercury's heavily pockmarked surface – but this crater will be too small to see from Earth, and the Hubble Space Telescope can't look at Mercury because it would have to point at the sun. That means astronomers won't get a good look at it until a joint European and Japanese mission, called BepiColombo, reaches it in 2024.

Election hogwash

HOGWASH, greenwash or whitewash? With just a week to go before the UK general election on 7 May, the main parties stand accused of offering bold claims about combating climate change and boosting clean technologies, but making few specific promises.

The criticisms come from economists, who have scrutinised the environmental promises of the main parties. "Much of the discussion is largely rhetoric, with limited focus on actionable

policy commitments," says the review, released on Friday.

For example, although Labour has pledged to make the UK a world leader in clean technology, creating 1 million jobs in the process, it has failed to say how much it will invest to that end, says Ralf Martin of the Centre for Economic Performance at the London School of Economics. "No one says that they will double or triple the R&D budget for clean technology," Martin adds. "It's all very unspecific promises."

He also worries that once the economy bounces back, we might see carbon emissions creep up.

Malaria milestone

IT'S tantalisingly close. The world's first malaria vaccine could win official approval by the end of the year, following promising trial results announced last week.

The RTS,S vaccine was tested in seven African countries in thousands of very young children. They had three injections within two months, and a booster dose 18 months later. After four years, the vaccine had cut cases of malaria by 36 and 26 per cent in groups aged 5 to 17 months and 6 to 12 weeks at first vaccination (*The Lancet*, doi.org/34s).

There were 198 million malaria cases in 2013, so using the vaccine could prevent of millions of cases, says Brian Greenwood of the London School of Hygiene and Tropical Medicine.

Developers GlaxoSmithKline (GSK) have applied for the vaccine to be approved, and the European Medicines Agency is expected to decide in September. In anticipation, the World Health Organization has assembled a panel that will meet in October to debate whether to make RTS,S routine for children in Africa.

However, a GSK spokeswoman says that even if the vaccine is approved, it could take two more years to get the green light in individual African countries.

Meter snitch fears

IS YOUR washing machine spilling secrets? Having a smart meter collect and share data on how our appliances use energy would make a fifth of people in the UK "uncomfortable".

Given that the UK government wants all homes to have smart meters by 2020, it has some persuading to do, says Alexa Spence of the University of Nottingham, UK, who carried out an online survey of 2400 people.

The meters allow users to program equipment to switch on at times when the grid has spare

capacity and power is cheap. That could cut electricity costs. But people are increasingly aware of the value of personal data and privacy, so often want to err on the side of caution, Spence says.

Those most worried about fuel

"People are increasingly aware of the value of their personal data and privacy, so want to be cautious"

billings were also the most fearful, whereas those concerned about climate change tended to be more amenable to data sharing (*Nature Climate Change*, doi.org/35j).

Poultry apocalypse now

HOW many birds must die? Some 13 million chickens and turkeys are being culled to stop the spread of H5N2, an offspring of Asia's H5N1 bird flu.

H5N2 is rampaging across the US Midwest, and while it poses little threat to humans, the country's \$45 billion poultry industry is already suffering. Iowa, the top egg-producing state, killed 3.8 million hens on one farm alone. US agriculture officials hope the outbreaks will diminish as summer warmth destroys flu viruses in the environment. But wild ducks could infect the rest of the continent in the autumn.

Producers are calling for a poultry vaccine, and the US Department of

Agriculture says it is developing one. The problem is that this may just make the situation worse.

"Vaccination will always be the last option for avian influenza," says Henry Wan of Mississippi State University, who discovered H5N1 in 1996. Widespread poultry vaccination in China, Indonesia and Egypt has not got rid of that strain.

On the contrary, vaccinated poultry transmit the virus without getting sick, making its spread "silent". Vaccination has driven H5N1's evolution as these viruses adapt to the birds. China is now trapped, say researchers: it wants to give up expensive vaccination, but if it did, ubiquitous, silent H5N1 infections would decimate unvaccinated birds.



Birds face virus threat

60 SECONDS

Blame climate change

Extreme heatwaves and heavy rain storms have become much more likely to happen globally as a result of the 0.85°C rise in temperature since the industrial revolution. Three out of four heatwaves are now down to global warming (*Nature Climate Change*, doi.org/35h).

Bat-winged dinosaur

A small, 160-million-year-old dinosaur fossil discovered in China and named Yi qi - "strange wing" - has a wrist structure resembling that of bats and flying squirrels. Its elongated fingers appear to have been webbed with a membrane that could have been used for gliding or even flight (*Nature*, DOI: 10.1038/nature14423).

Chimp spine = back pain

Slipped disc? You may be less well adapted, evolutionarily speaking, to walking upright than others. A comparison of vertebrae from orangutan, chimp and human skeletons revealed that the spines of humans with a slipped disc were more similar to chimps' spines than healthy human spines (*BMC Evolutionary Biology*, doi.org/35m).

The ages of obesity

If you were overweight as a baby, blame your parents, but if you were a little too plump as a teen, blame your friends. This is the upshot of a comparison of childhood obesity data from the 1980s and 2010. Researchers say this shows different measures are needed to tackle the problem at different ages (*International Journal of Obesity*, in press).

Real fast food

Driver, where's my dinner? Taxi firm Uber has just launched UberEats in New York, Los Angeles, Chicago and Barcelona, where it will bring meals to customers within 10 minutes for a \$3 to \$4 surcharge on their order. The service delivers the food to the curb to save time.

Starting gun fired on gene editing

The age of changing human genes has begun. Here's your guide to the next medical revolution

Penny Sarchet and Michael Le Page

GENE editing is here. The first work attempting to edit human embryos grabbed headlines last week. And another study showed how gene editing might prevent children inheriting disease.

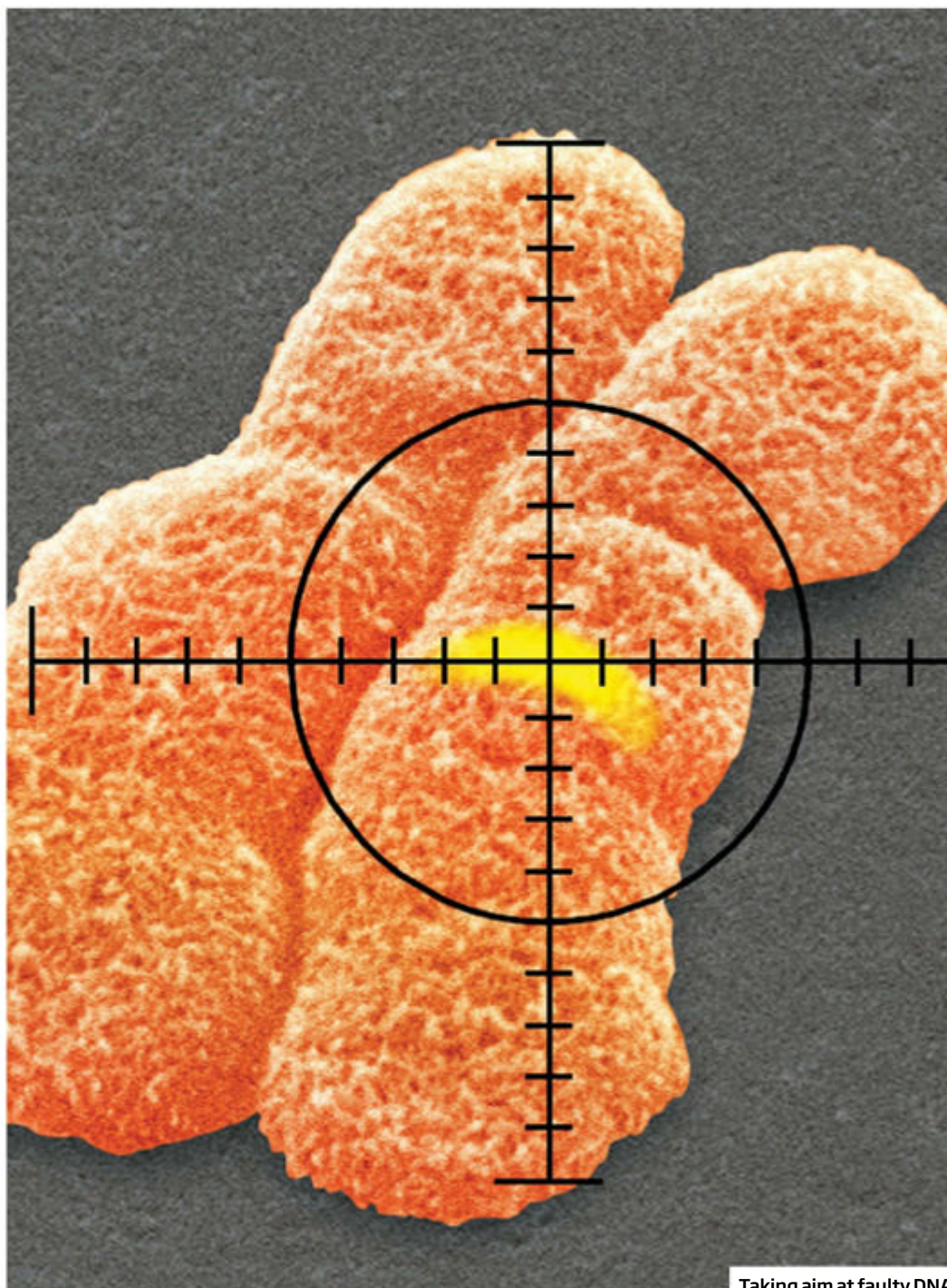
It could be decades before it is safe to snip out and replace stretches of DNA to genetically engineer babies – even if it is deemed ethically acceptable. But the approach is already being tested for treating disease in adults and could soon be used to treat a wide range of disorders.

It has been a long time coming. Rudimentary editing methods were first developed some 30 years ago, but only now have techniques been honed to the point that they can be used for treating people. It raises the curtain on a new era of genomic tinkering and genetic medicine.

HIV therapy

In the coming months, four US clinics will recruit people with HIV to a trial of a therapy based on gene editing. HIV wreaks havoc by destroying immune cells called T-cells. It does this by exploiting a receptor, CCR5, on the surface of these cells. Destroy the gene for CCR5 and you can block infection.

Last year, researchers targeted and destroyed this gene in the T-cells of 12 people with HIV using custom-made proteins called zinc finger nucleases. This raised their resistance to the virus. The new trial goes further, knocking out the gene in the stem cells that give rise to T-cells, making it a possible one-shot, lasting treatment. “The goal is a functional cure,” says John Zaia, of the City of Hope



POWER AND SYRED/SCIENCE PHOTO LIBRARY

Taking aim at faulty DNA

hospital in Duarte, California. The trial blazes a path for using the approach to treat other diseases. For example, another trial set to start soon will focus on sickle cell disease, in which the oxygen-carrying haemoglobin molecules in red blood cells are abnormal. The technique would switch on a protein that can be used instead of the haemoglobin.

There could be downsides to this approach though. “Genome editing offers both tremendous promise and significant potential risk,” says David Liu of Harvard University. Almost all editing techniques have the potential to modify unintended DNA sequences, he says. “Some of these off-target genome modification events will likely lead to negative biological consequences.”

But, if it can be made safe, editing adult stem cells is likely to face fewer ethical hurdles than other applications of gene editing.

Inherited change

Some teams are already exploring the possibility of using gene editing to make heritable changes. Last week, researchers showed that gene editing can weed out mutations in the mitochondria that a female mouse passes on to her offspring.

Mitochondria generate energy in our cells and have their own set of DNA, which differs from that in the cell nucleus. Mutations in mitochondria can cause diseases for which there are no treatments.

Earlier this year, the UK gave the green light to mitochondrial replacement therapy. This involves creating “three-parent babies” with healthy mitochondria donated from a third person preventing such diseases being passed on.

The new approach offers an alternative. It uses a gene-editing technique based on custom-made proteins called TALENs. These proteins can be designed to latch on to the DNA in faulty mitochondria and target them

HOW TO EDIT GENES

TARGET A SPECIFIC SEQUENCE
For the TALENs or zinc finger gene editing systems (see main story), this requires designing proteins to bind to the DNA you want to edit. With CRISPR, only RNA complementary to the target DNA is needed. It takes days to make these, but customised proteins take years.

CUT THE TARGET DNA
This is the easy part - enzymes cut your chosen DNA.

HIJACK DNA REPAIR SYSTEMS
Cells repair any strands of cut DNA using the nearest matching DNA as a template. So if you supply the template DNA, you can trick cells into making the changes you want.

for destruction. Healthy mitochondria remain unharmed.

Most women at risk of passing on faulty mitochondria carry some healthy and some mutated mitochondria, so TALENs could lower the number of mutated mitochondria in their eggs. Harmful effects only kick in once the number of mutated mitochondria crosses a threshold, so this may be enough to prevent disease in their child, and perhaps in future generations too.

Using gene editing in this way isn’t without risk, says Robert Lightowlers at Newcastle University, UK. It is unclear whether reducing the number of mitochondria could have a long-term effect, he says. And although

the TALENs protein in the study seemed to target only the intended mitochondria, it could be harmful if even a very low amount of it got into the nucleus and altered DNA there.

Juan Carlos Izpisua Belmonte of the Salk Institute for Biological Studies in La Jolla, California, who is part of the team doing the TALENs work, says they plan to begin testing the safety of the technique. “The idea will be to obtain oocytes and discarded embryos from IVF treatments in order to test this technology using human samples.”

Taking the research to the next level will be controversial. Last month, a group of scientists called for a moratorium on gene editing research in cells that can form embryos. The plea was made by those working on gene editing with adult cells who are concerned that embryo editing could have unpredictable effects on future generations and stimulate a public outcry.

Uncharted waters

Despite the call for a hiatus, a team in China announced last week that it had edited DNA in the nucleus of human embryos.

The work involves a technique called CRISPR/Cas9, developed in the last few years. It has the potential to accelerate progress enormously because CRISPR is much faster than conventional gene editing methods (see “How to edit genes”, left).

Despite the hype, there

is a long way to go before CRISPR could be used to write genetic disease out of the DNA of future generations. The Chinese study flagged up a number of potential problems. Of the 86 eggs injected, just four were successfully modified. And the resulting embryos were a mosaic of modified and unmodified cells.

This may have been down to the unviable embryos used, which were created when two sperm fertilised the same egg. The team said it used them because ethical concerns preclude the study of gene editing in normal embryos. But that hasn’t stopped the work being criticised.

The fuss is because it is the first phase of a more controversial effort to make genomic changes in human embryos intended to be implanted, says George Annas of Boston University. “It is only in the context of this wider project that manipulation of non-viable human embryos moves from curiosity to potentially dangerous – both to the resulting children and their children, and to society at large,” says Annas. These concerns over designer babies are less of an issue for mitochondrial gene editing because it is only possible to delete mutant mitochondria, not alter them.

Yuet Kan of the University of California, San Francisco, describes the study as a publicity gimmick. The disease it targeted, beta-thalassaemia, can already be detected by pre-implantation embryonic screening during IVF. “I don’t see any need for embryo gene editing,” says Kan, who is using CRISPR to treat HIV.

Despite the controversy, at least one group in the US and several more in China are also reportedly working with human embryos. But when it comes to treating disease in the near future, it is the adult methods that hold the most immediate promise. One thing is for sure, the gene-editing genie is well and truly out of the bottle. ■

TREATING DISEASE	PREVENTING DISEASE...	
...BY MODIFYING GENES IN ADULTS	...BY DESTROYING MUTANT MITOCHONDRIA	...BY MODIFYING GENES IN EMBRYOS
Human trials under way	Testing in human cells about to start	Testing in human embryos under way
PROS: Could be used to treat all kinds of diseases and disorders	PROS: Could prevent mitochondrial diseases without using a donor	PROS: Could prevent many genetic disorders
CONS: Could turn cells cancerous if the wrong bit of DNA gets modified	CONS: Effects are heritable, so ethically controversial	CONS: Uncharted ethical and scientific waters; treatments are a long way off

Now just relax, no one can see you

Anil Ananthaswamy

IT'S the superhero power that everyone wants. A whole-body version of the classic rubber hand illusion is helping us find out what it's like to be invisible.

Over 15 years ago, psychologists found they could convince people that a rubber hand was their own by putting the fake hand on a table in front of them and stroking it and the person's own hand at the same time.

In 2008, Henrik Ehrsson at the Karolinska Institute in Stockholm, Sweden, and his team extended this illusion to the full body by taking a life-size mannequin with cameras for eyes, and pointing its head towards its abdomen. A human volunteer stood facing the mannequin, and wore virtual reality goggles displaying a video feed from the mannequin's cameras. When researchers stroked both the volunteer's and the mannequin's abdomens at the same time using brushes, people reported feeling that the mannequin's body was their own.

But do you even need the mannequin for the illusion to

work? To find out, the researchers pointed the cameras at a region of empty space. Again the experimenter stroked the volunteer's abdomen, but this time they moved the other brush in the air in front of the cameras, as if someone was standing there.

The researchers tried it out on

themselves first. "I am very susceptible to illusions, so for me it worked," says team member Arvid Guterstam. "You have a vivid sensation of having a body, but it's not directly visible. I don't know what it would feel like to have a phantom body, but I imagine that's what it'd feel like."

The team carried out a series of experiments, each involving about 20 people. About 75 per cent experienced the illusion (*Scientific Reports*, doi.org/34m). "Most were surprised, and some started giggling. It's a very unnatural,

unexpected experience," says Guterstam. "It's the first time that anyone has shown that you can embody a full invisible body."

Once the illusion had taken hold, the volunteers were asked to look up. Now what they saw in the goggles was a group of people, wearing serious expressions and looking down at them. Volunteers in the grip of the mannequin illusion also went through this. When the team measured everyone's heart rates, they found they were lower when people felt they were invisible than when they felt they were embodying the mannequin.

"If you are truly experiencing a non-physical body, it should also be represented in the brain as invisible to outside observers," says Guterstam. This probably reduced the stress the subjects felt when stern-looking faces were gazing down at them.

Next, the team plans to use brain imaging to observe neural activity as the illusion takes hold. They also want to investigate whether the feeling of invisibility affects how we make moral choices, and whether it's possible to give people the illusion of having an invisible face.

"The invisible body illusion is definitely pushing the boundaries of what the brain can accept as part of the bodily self," says Guterstam. ■



GROUP EHRSSON BRAIN, BODY AND SELF LABORATORY/KAROLINSKA INSTITUTE

A brush with invisibility

Iceland doubles for Red Planet in camera test

TO A Martian, Iceland's volcanic landscape might look a bit like home. No wonder the camera for the next Mars rover just did a test run there.

The PanCam (for Panoramic Camera) is set to travel aboard the European Space Agency's ExoMars rover in 2018. "It looks like a three-eyed monster," says Claire Cousins, a planetary scientist at the University of Edinburgh, UK. Two

"eyes", on the right and left of the unit, scan the terrain for noteworthy features. They also switch between filters set to different wavelengths in order to pick up subtle spectral properties of minerals - a clue to their composition. Nestling between the two is a high-resolution camera.

Once the rover arrives on Mars in January 2019, it will drill as deep as 2 metres for soil samples. In their structure and chemical make-up, these could hold important clues to any early Martian life. Choosing promising spots to drill is tricky, however.

That's where PanCam comes in. Its multispectral eyes will search the local

rocks for signs that the environment is hospitable to life, or was in the past. Clay minerals, for example, would have formed in the presence of liquid water, while certain sulphates might suggest the soil is too acidic for life to thrive.

To see if PanCam is up to the task, Cousins's team took a prototype to Námafjall, a volcanic region in north-east Iceland. There, they mounted the camera at roughly its

"It looks like a three-eyed monster, with an eye on either side to scan for noteworthy features"

operating height on the rover, and made it survey the region. Lab testing of samples collected in Iceland helped to confirm that the camera picked out important minerals correctly (*Icarus*, doi.org/34v).

The team hopes to test the camera at other Mars-like spots on Earth - a good idea, says Brian Hynek at the University of Colorado in Boulder. "For science, more tests should be completed in other environments," he says, like places with lakes or deltas where ancient life might be preserved in sediment. "This might be the more likely type of environment in which ExoMars will land." Aviva Rutkin ■

Low-key Milky Way lacks dark matter skeleton

THE Milky Way has had a sheltered life. A search for the signs of a violent galactic upbringing has come up empty, and the finding is helping astronomers understand our galaxy's history. It could also aid the search for dark matter.

Galaxies are shape-shifters. Far from being a single set of stars in an eternal spiral, the Milky Way has devoured countless smaller galaxies over its 13 billion year lifetime, and its shape has been in constant flux to accommodate the immigrants. It is riddled with alien stars, threshed from foreign

galaxies as they joined ours. dig found no alien stars in the main disc – although they found plenty on more sedate orbits in the galaxy's suburbs. That suggests that the Milky Way has been steadily gobbling smaller galaxies, but nothing large enough to force new stars and dark matter directly into the disc (arxiv.org/abs/1504.02481).

If the Milky Way lacks a dark matter disc, this has implications for physicists hunting the elusive substance. Dark matter makes up 80 per cent of the universe's matter but only interacts with ordinary matter via gravity, so it is difficult to detect directly.

Earth-based experiments hope a dark matter particle will collide with an ordinary atom in an observable way. Dark matter particles from the galactic disc will give different signals to those from the halo of dark matter the Milky Way was born with – without a disc, the problem is more clear-cut.

Kevin Schawinski of the Swiss Federal Institute of Technology in Zurich says the findings are helpful for comparing the physics of the Milky Way with other galaxies. "The fascinating thing about the Milky Way is that we know it in gorgeous detail because we're in it, but it's also hard to put it in context for the same reason," he says. "We want to know how we got here and how the universe works. Our society and civilisation is the first one that has creation stories that might actually be true. The Milky Way is great, but how did it get that way?"

It would be good to know, since the Milky Way's quiet life is about to end. In 4 billion years, it will collide with its nearest major neighbour, Andromeda, which is roughly the same size and had a much more violent youth. When our stars and dark matter merge, our galaxies' histories will merge too. **Hal Hodson** ■

"Our society and civilisation is the first one that has creation stories that might actually be true"

galaxies as they joined ours.

If these galaxies were big hitters, the forces unleashed by a merger would push stars into the heart of our galaxy and create a flattened disc of accreted dark matter that lines up with the spiral disc of stars.

"If you have a disc galaxy and then you have a substantial merger, material is preferentially pulled towards the disc as [the merging galaxy] gets tidally torn to pieces," says Justin Read of the University of Surrey, UK, a co-author of the new study. "Because those shredded satellites will contain stars and dark matter, we can look for evidence that this has happened by picking through the stars in our backyard."

So Greg Ruchti of Lund University in Sweden and his colleagues searched through 4675 Milky Way stars from the Gaia-ESO Spectroscopic Survey looking for remnants of a large merger. They wanted stars with alien chemistry that were a little hotter than Milky Way natives, but rotating at the same speed.

But their galactic archaeological



No big collisions... yet



ROYAL SOCIETY OF CHEMISTRY

Get ready for the Emerging Technologies Showcase 2015

Join us on 29 June for the Royal Society of Chemistry's flagship event, where innovation takes the stage.

The daytime event:
Burlington House, Piccadilly

The winners announcement:
BAFTA 195 Piccadilly

Register at <http://rsc.li/et15>
#RSCEmergingTech

Registered charity number: 207890



Where complex life first bit the dust

Eaten, turfed out... pity the Ediacarans

Jeff Hecht

STRANGE and largely immobile organisms living on the seafloor were the first complex life on Earth. Appearing 579 million years ago, they thrived for some 37 million years, then vanished—becoming a curiosity we know only from faint impressions in the sandstone fossil record.

Why did they die out? New fossil evidence suggests that these creatures, known as Ediacarans, had their world turned upside by

an explosion of life forms at the start of the Cambrian period 541 million years ago. Some may have evolved to eat their enigmatic predecessors, and may also have changed the environment in ways that doomed them.

If so, the first mass extinction of complex life had a biological cause, unlike Earth's big five mass extinctions, which were driven by environmental events—such as volcanic eruptions that poisoned the oceans.

The disappearance of the

Ediacarans from the fossil record has long troubled biologists. Leading theories are an environmental mass extinction; or that the Ediacarans got eaten or had their habitat destroyed by newly evolved animals; or that they no longer left fossils because of a change in ocean conditions.

But when Marc Laflamme of the University of Toronto in Mississauga and colleagues reviewed fossil data, they found no evidence of an environmental catastrophe. And given that soft-bodied Cambrian animals did fossilise, it seems unlikely that any surviving Ediacarans would not have done so.

The team's search for answers took them to southern Namibia, where outcrops expose fossils

from the crucial few million years when the Ediacarans disappeared and the Cambrian animals appeared. The deposits there show a vast rise in trace fossils from Cambrian animals, indicating they were breaking up sediment and disturbing the Ediacarans' habitat.

"Modern animals are ecosystem engineers," says Simon Darroch of the Smithsonian Institution in Washington DC, who will detail the team's evidence next week at the Joint Assembly of the American Geophysical Union in Montreal, Canada. By a number of measures, such as low species richness, he found that the Ediacarans fossil communities looked "very stressed".

Among the newest Ediacaran fossils, Darroch also found traces very similar to those left by sea anemones, which are predatory. "So there probably were predators in the late Ediacaran," he says. All of this adds up to pretty robust evidence that the new species ate the old ones or destroyed their habitat, he says.

"Clearly there was an extinction of the big fleshy things stuck on the seafloor," agrees Jim Gehling of the South Australian Museum in Adelaide. But he adds there is evidence that some Ediacarans evolved movement and ways of ingesting food like modern animals, and may have survived to become the distant ancestors of later life forms. ■

Microbes play villainous role in Arctic warming

THEY'RE collaborating with the enemy. Climate change in the Arctic may be getting a helping hand from microbes, whose effect could thus be underestimated in climate models.

Mette Svenning from the University of Tromsø, Norway, and her team found that microbe communities potentially produce more greenhouse gases than we thought. We knew that

higher temperatures speed up the rates at which microbes in the Arctic soil release methane—a greenhouse gas 25 times more potent than carbon dioxide. But the team found it took just a month for entire communities to adapt to rising temperatures and release more methane.

The microbes were surprisingly effective at low temperatures. While communities from warmer climates grind to a virtual standstill at 4 °C, their Arctic relatives continue producing methane at a quarter of the rate that they would at 27 °C (PNAS, DOI: 10.1073/pnas.1420797112). The

temperature rises above 4 °C are increasingly being reached during the longer summer seasons.

Arctic soils hold twice as much carbon as the entire atmosphere, so the impact of methane-emitting microbes could therefore push up temperatures by an extra 0.13–0.27 °C by the end of the century.

There are indications that microbes may also make sea ice melt faster. In

"Climate models that do not include biological factors could underestimate the scale of changes to come"

liquid water, the dark bodies of marine phytoplankton absorb more of the sun's rays, which could warm the surrounding Arctic waters by 20 per cent more than current climate models predict (PNAS, doi.org/34r). On top of this, plants and bacteria that live on glaciers and snow banks do similar things on land ice.

Too little data exists on biological influences, says Jørgen Hollesen from the University of Copenhagen in Denmark. But he says climate models that do not include these factors could be underestimating the scale of the changes to come. Jan Piotrowski ■



SCI-FI-LONDON

THE ANNUAL INTERNATIONAL FESTIVAL OF SCIENCE FICTION AND FANTASTIC FILM

The UK's leading genre film festival
where what if meets wtf

BFI Southbank and across London

29 MAY — 7 JUNE 2015

SCI-FI-LONDON.COM @SCIFILONDON



FILM

WATCH SCI-FI

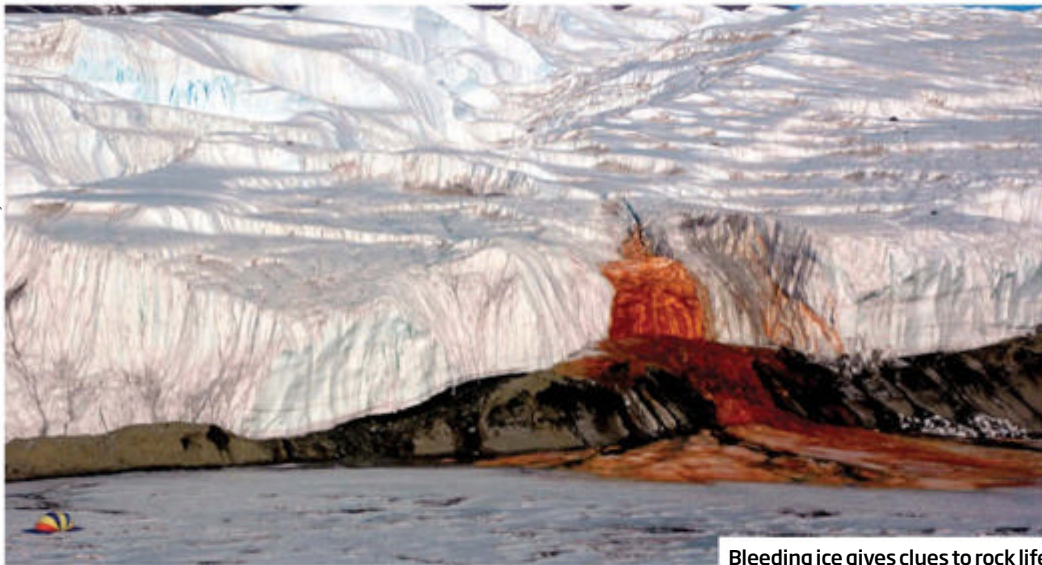
fcml



audible.co.uk
an amazon company

SFX

NewScientist



Bleeding ice gives clues to rock life

Antarctic aquifers may teem with life

Colin Barras

ANTARCTICA'S Blood Falls are well named. There, the white tongue of the Taylor glacier is stained crimson, as if the ice itself has been wounded. The iron in the water – which oxidises to give the falls their vivid red colour – comes from the weathering of the bedrock beneath the ice, a process enhanced by microbial action.

"This unique feature is much more than a curiosity – it is a portal into the Antarctic subsurface, a hint at what lies beneath," says Jill Mikucki at the University of Tennessee in Knoxville.

We already know that there is liquid water – and life – in some of the lakes beneath Antarctica's ice. Blood Falls is a sign of something else: that the ground, too, holds liquid water, and that it may have extensive microbial activity. The falls are perhaps the only place where this groundwater comes to the surface. They flow just a few times a decade, possibly driven by changes in the weight of the ice above.

Now a study by Mikucki and her colleagues has found this groundwater could be surprisingly extensive. They used an electromagnetic sensor attached to a helicopter to map electrical resistivity in the relatively ice-free Taylor valley, to the east of Blood Falls.

Resistivity shoots up by several orders of magnitude when soil water freezes. So by looking for areas of the valley where resistivity readings were low, the team could map the extent of the subsurface water. Their results

"The microbe-rich water of Blood Falls suggests that life persists throughout the Antarctic subsurface"

revealed large bodies of liquid in ground 185 metres below the surface, forming aquifers that stretch down the valley and apparently into the Ross Sea, a deep bay of the Southern Ocean (*Nature Communications*, doi.org/35q).

"This may be the most different

of all liquid water reservoirs on Earth, since it is not directly replenished by infiltrating rainwater or seasonal snowmelt," says Slawek Tulaczyk at the University of California, Santa Cruz. He adds that there is no reason why similar groundwater bodies should not exist elsewhere beneath Antarctica.

The groundwater is cold, deep and twice as salty as seawater, but the water streaming out of Blood Falls, which teems with microbes, tells us that it is unlikely to be lifeless. "The fact that the [water] contains metabolically active microorganisms that appear to be suited to life in a dark, cold brine supports the idea that life should persist throughout the subsurface," says Mikucki.

If so, those microbes could be fuelling life in the Southern Ocean. By breaking down iron-containing rocks they might be dumping as much as 170 million kilograms of iron into the ocean each year, according to the researchers' estimates. That could explain why marine life is seasonally abundant near the coast. However, we don't yet know whether this happens, cautions Mark Moore at the University of Southampton, UK – the iron might simply react and be lost where the groundwater meets the sea. ■

Brain gives up making sense of weird dreams

YOU open your front door to find your boss – who is also a cat. The bizarre can seem completely normal when you're dreaming, perhaps because parts of your brain give up trying to figure out what's going on.

Armando D'Agostino of the University of Milan in Italy decided to investigate the strangeness of dreams. His team asked 12 people to keep diaries in which they were to write detailed accounts of seven dreams. When volunteers could remember one, they were also told to record what they had done that day and come up with an unrelated fantasy story to accompany an image they were given.

Using a "bizarreness" scoring system, the researchers found that dreams were significantly weirder than the waking fantasies the volunteers composed (*Journal of Sleep Research*, doi.org/3wk). "It seems counterintuitive, but there was almost no bizarreness in fantasies," says D'Agostino. "There are logical constraints on waking fantasies, and they are never as bizarre as a dream."

A month later, the reports were read back to each of the dreamers while their brain activity was monitored with an fMRI scanner.

Both dreams and fantasies seemed to selectively activate a set of structures in the right hemisphere of the brain associated with complex language processing. Curiously, the activity in this area appeared to decrease as the narrative became increasingly bizarre. It is almost as if the brain is giving up trying to make sense of the dream, says D'Agostino.

"It's a legitimate theory," says Patrick McNamara at Boston University. He thinks bizarreness may result from the brain's attempt to symbolise complex emotions as it tries to store memories. "When emotions are intense, they are harder to symbolise, so perhaps the dreams are more likely to be bizarre," he says.

Jessica Hamzelou ■

Upp™



FUEL CELL TECHNOLOGY

Tomorrow's technology today, available at BeUpp.com/fuelcell



Upp is a portable fuel cell power solution. Technology used in space exploration and land-based vehicles has been developed further into a unique, next-generation power pack. Upp consists of two parts, a MicroGenerator and fuel cartridge. Using hydrogen as the fuel, Upp creates electricity instantly on-the-go for your smartphone and other compatible USB devices. What was once big and expensive is now smaller and affordable and ready to use.

**Find out more about Upp
at BeUpp.com/fuelcell**



BeUpp.com

Morning pick me up



Lasting pick me up



**Subscribe for
less than \$2 per week**

Visit newscientist.com/8032 or call
1-888-822-3242 and quote offer 8032

NewScientist



Giant magma chamber found under Yellowstone volcano

The supervolcano below Yellowstone just got bigger. Under the national park in Wyoming is a chamber holding enough magma to fill the Grand Canyon 11 times over.

We knew there was magma under the surface, in a 10,000-cubic-kilometre chamber. Now a second chamber has been discovered, 20 to 50 kilometres down, with a capacity of 46,000 km³. Together, the two form the largest known magma reservoir in the world, says Fan-Chi Lin of the University of Utah in Salt Lake City.

Previous studies failed to find the chamber because the seismic waves used to visualise deep areas were

distorted by rock closer to the surface. Lin's team got round this by combining readings from shallow and deep waves (*Science*, doi.org/32r).

The discovery helps to solve two long-running puzzles: how the smaller chamber could produce the 45 kilotonnes of carbon dioxide discharged daily from Yellowstone's volcanic system, and also how molten material from the mantle, around 60 kilometres down, could travel so far upwards. "We have a much better understanding of how the entire magmatic system works, from the mantle to the surface," says Lin.

Despite the quantity of magma, the risk of the supervolcano erupting remains very low. Lin says the team's findings can be applied to other volcanic systems around the world to help predict volcanic activity.

Paper becomes a light-emitting display

PAPER, light thyself. A light-emitting display has been created out of ordinary paper. It could one day make disposable displays for packaging or newspapers, using cheap and environmentally friendly materials.

Ludvig Edman from Umeå University in Sweden and his team sprayed six layers of different materials onto a piece of paper: an adhesive, four layers that carry

current and turn electricity into light and a capping layer to keep it all in place. When juiced with 11 volts, the paper glows as bright as many computer displays.

Edman says it could be a low-cost alternative to LEDs, which are usually used for illumination, and OLEDs, which are used for high-end displays. LEDs are efficient but expensive, so a cheap, eco-friendly version could have traction. The

light can be printed in the same way as a newspaper, is highly flexible and, unlike glass displays, doesn't break into dangerous shards (*Advanced Functional Materials*, doi.org/f27f9b).

Other uses for light-emitting paper could include tagging goods so that they automatically light up when close to their expiry date, notifying a patient who has forgotten to take their medication, or easily tracking and identifying packages in a big pile.

Jigsaw dinosaur has bits of many others

IT'S *T. rex*'s bizarre vegetarian relative. *Chilesaurus diegosaurezi* was discovered in southern Chile where it lived around 150 million years ago (*Nature*, doi.org/34t). Strikingly, it looks like a mosaic of several other dinosaurs. It had a tiny head, a 3-metre-long body and small arms like *T. rex* – but with blunt fingers instead of raptorial claws. And unlike *T. rex*, it had broad hind feet more like those of *Diplodocus*, while its pelvic girdle tipped back like that of *Triceratops*.

"*Chilesaurus* constitutes one of the most bizarre dinosaurs ever found," says Fernando Novas of the Argentine Museum of Natural Sciences in Buenos Aires. "It doesn't belong to any recognised theropod lineages, but represents an evolutionary jigsaw puzzle." The find challenges the prevailing theory that theropods were first carnivores, and only evolved into lumbering herbivores much later.

Mini lab tests drugs inside a tumour

YOU need chemo, but which drug will kill the cancer? Injecting a mini diagnostic lab into the tumour could work better than the normal trial-and-error approach.

A device developed by Presage Biosciences in Seattle uses six needles to inject different drugs, along with coloured dyes, into a tumour. After 24 hours, part of the tumour is removed, and the various dyed regions inspected to see which drug killed most cells.

In mice, the device correctly predicted which drugs worked best. Studies in people showed it caused only mild discomfort (*Science Translational Medicine*, doi.org/339). "This can fast-track our ability to rethink standard chemotherapy," says Neil Watkins of the Garvan Institute in Sydney.

Tinnitus is a little bit in your head

WISH you knew how that mysterious ringing in your ear got started? Peeking inside the brain of a man with tinnitus - the debilitating sensation of hearing a noise with no apparent source - has revealed new clues.

William Sedley at the University of Newcastle, UK, and colleagues took the chance to study brain activity in a man with tinnitus who had surgery to treat epilepsy. When surgeons placed electrodes in his brain to identify the source of his seizures, they found that several kinds of brainwave associated with tinnitus were more widespread than previously thought.

The man's tinnitus was linked to higher than normal activity in the primary auditory cortex - an area of the brain involved in the initial processing of sound - as well as in other brain areas involved in the wider perception of noises, such as those that control attention, memory and emotion (*Current Biology*, doi.org/338).

There is some evidence that people with tinnitus perceive sounds that wouldn't normally enter one's consciousness. "What has held back treatments is that we don't know what we're trying to target," says Sedley. "A better understanding of the brainwaves that underlie tinnitus might help to refine or inspire new treatments."



WESTBURY/GETTY

Copy your rivals if you want to win the cup final

DREAMS and careers rest on the decision. Do you go all out in the semi-final or rest your stars so they are fresh for the final?

Seung Ki Baek of Pukyong National University in Busan, South Korea, and his colleagues have applied game theory to this "semi-finalists' dilemma", and the results could apply in the boardroom as much as in basketball or football.

In a winner-takes-all tournament, the best strategy is to copy what everyone else does, the team says. If your opponents

rest their stars, you ought to as well. Otherwise, you risk being more tired than the opponent in the final. This sort of scenario, in which no player has an incentive to go off-strategy, is what game theorists call a Nash equilibrium.

But it's different when there's the chance of redemption in a third-place play-off. You need to introduce an element of chance to catch your opponents off guard, says the team. Either go all out in the semis, or save everything for the next match. A team may be crushed in the semi-final, but

saving energy increases the odds of taking home a prize: the bronze (*Physical Review E*, bit.ly/semifinalmaths).

The results could also guide companies in setting incentive schemes. "The pay-off system is effectively sending a signal to people on how to behave," says Baek. For instance, a company wanting to cultivate specialists on its management team may wish to avoid paying the CEO far more than others, because that might push people to develop the same skill set to compete for the top job.

Tell twins apart by melting DNA

WHODUNNIT? Standard DNA analysis can pin down a criminal, but not if the suspect has an identical twin. Now a test involving melted DNA could tell twins apart in a few hours.

To find out whether a suspect's DNA matches that recovered from a crime scene, forensic scientists compare parts of sequences that are particularly variable between individuals. But identical twins share the same genetic code, so Graham Williams at the University of Huddersfield, UK, wondered whether modifications to twins' DNA as a result of their lifestyles could help tell them apart.

Such epigenetic changes occur when a gene gets modified in response to environmental factors. Williams's group used a chemical to alter the melting point of DNA in a way that reflects the number of changes in that particular sequence. When they heated five pairs of twins' DNA samples, they could tell them apart from the different melting points. In an investigation, the perpetrator would be the twin whose DNA melting point matched that of the sample from the crime scene (*Analytical Biochemistry*, doi.org/33r).



ADRIANA SALOMAO

Frogs dig underwater love chambers

GET a room. Loved-up torrent frogs have found an ingenious way to procreate far away from predators - by building a secret underwater love chamber.

Fábio P. de Sá from São Paulo State University in Brazil and his team observed *Hylodes japi*, a newly discovered species, in the forests of Brazil. Male torrent frogs serenade females near fast streams. A successful male then takes his new partner on an underwater tour.

It takes an eager pair of frogs just 5 minutes to pick a spot for the male to carve out a chamber. He does this

by excavating the sand around small rocks at the bottom of the stream. Then he invites his mate into the love nest, which is only just big enough to fit the two amorous amphibians.

After the female has laid her eggs inside, the couple leave the chamber. They then work together to conceal the entrance with sand (*Herpetologica*, doi.org/32q).

"Hiding eggs inside an underwater chamber may increase protection of offspring against the strong water flow, predation and potential cannibalism [by other tadpoles]," de Sá says.



GET INSIDE YOUR OWN HEAD

The Human Brain uncovers everything you need to know about the most complex object in the known universe

Buy your copy now from all good newsagents or digitally. Find out more at newscientist.com/thecollection

NewScientist



Why not put clipboards in the cloud?

Mining for every vote

Will the forthcoming UK elections be won by the party that's best at making sense of data, asks **Jacob Aron**

WITH just one week to go until the most unpredictable UK general election in a generation, you'd think that every vote counts.

Not so. If you have already decided who to vote for, know when you'll be going to the polling station, and plan to stay up all night to watch the results come in, the politicians don't care about you.

The two biggest parties, Labour and the Conservatives, are fighting a surge in support for what had been minor parties. The only predictable outcome is a hung parliament, in which no party has an overall majority. That means it's the undecided, unmotivated and uninterested voters who will decide this

election, if they can only be coaxed to the polling booths. Increasingly, parties are turning to data mining to get them on board.

The 2012 US presidential election, which Barack Obama won in part due to the Democrats' ability to target certain voters, showed the power of having a solid data team as part of the campaign.

"There is a lot of opportunity to be increasingly clever," says Andrew Whitehurst of Wess, a London-based firm that runs digital campaigns for all three major UK parties. His colleague watched both sides in the last US presidential campaign drumming up support on the same street.

"The Romney camp knocked on every single door, and the Obama camp knocked on about seven."

With memberships at an all-time low, the UK parties don't have the ground troops to waste on the Republicans' mistake. Instead they need to use data to identify people who are most likely to support them, and to make the effort to cast their ballot.

The process starts with the electoral roll, which lists the name and address of everyone in the country who is registered to vote. Parties blend in any information

"It's the undecided and unmotivated who will decide the election, if they can be coaxed to the polls"

they have gathered about you from canvassing, along with consumer data and even social media profiles. "It's not just official data," says Whitehurst. "People are increasingly giving over more and more information about themselves."

In the US, the Democrats used this data to build a model that gives each person a score based on their support for a particular party and how likely they are to vote. These predictions can be plotted (see graph, opposite) such that the people at the edges aren't worth spending resources on: either they have already decided who to vote for, or they are entirely disengaged.

"In the middle are people who might vote and you know support you, or at least you think would support you if they had the right information," says Tiffany Washburn, a former data analyst for the Obama campaign and now at Google.

Replicating this in the UK is harder, as campaign spending

restrictions and data protection laws limit what parties can do. What's more, the multiparty nature of UK politics makes such modelling a headache. In the US, an environmentalist who supports gay marriage is almost certain to be a Democrat, but in the UK, ticking these two boxes doesn't pin down someone's party.

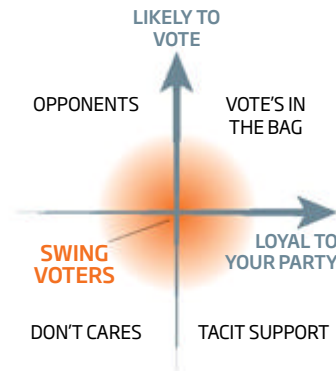
Instead, the parties must leverage information gleaned on the doorstep or through phone canvassing to make more generalised predictions, says Whitehurst. "They will try to develop profiles to say: we know you and we know loads of other people who fit into the same buckets. Can we then discern where other potential voters might be, who also fit this profile and who we haven't doorstepped?"

Having identified these people, the parties can decide how best to reach them, whether by knocking on doors, leafleting or emailing.

The latest addition to the arsenal is Facebook advertising that exploits information you've added to your profile. "Facebook allows quite a rich range of targeting options," says Mark Pack, who previously ran online campaigns for the third major UK

Aim at the middle

Winning elections is about identifying which voters to focus resources on



party, the Liberal Democrats. "That's the big difference now from five years ago."

Gathering that all-important canvassing data is also a challenge in the UK, where the humble clipboard still reigns supreme, hampering the ability to access and record voter preferences in detail. "People should be able to knock on doors holding an iPad and have the voter information right in front of them," says Anthony Ridge-Newman, a Conservative activist who explored the party's use of technology in a book entitled *Cameron's Conservatives and the Internet*. "As soon as they input

that data, it should be sent up and logged centrally."

Some parties allow activists to access voter data by smartphone or tablet, but this has not yet taken off, says Whitehurst. The Conservatives' Votesource system, for example, is so new that users are still on the learning curve.

Partly because parties can't always roll out cutting-edge techniques, a few candidates are going it alone with decentralised systems. One is an app called Kanto, which helps canvassers log voter's interests to the cloud. On polling day, users can also tick off people they know to have voted, ensuring no campaign resources are wasted.

Having accurate records makes campaigning three times more efficient, says Thomas Borwick,

"Transport for London data shows when to canvas commuters. Or try sweet-talking people on Tinder"

founder of Kanto Systems. "In a perfect system you have the right person knock on the right door, who has something in common with the voter, can engage them in a conversation and make sure they go to the polling station."

Other ad-hoc methods, says Whitehurst, include using constituents' emails to target people on particular issues, studying Transport for London data to figure out the busiest times to canvas commuters, or even trying to sweet-talk people using dating apps like Tinder.

The election's outcome could result in even more data mining. The Conservatives have promised a referendum on whether the UK should stay in the European Union – a nationwide, binary choice much closer to a presidential election, which should make US techniques easier to import.

"Winning elections nowadays is not really about convincing people, it's about mobilising people," says Whitehurst. ■

ONE PER CENT



Print my surgery

Nurse! Print me a femur, stat! Start-up Osiris Biomed 3D wants to print implants on demand during reconstructive surgery, based on live scans of a patient's body. The idea is to be able to fast-track people in urgent need of surgery. The firm won a pitch competition earlier this month at the New York 3D Printing Conference and Expo.

"The cool thing about these guys is that they have really, really, really long trunks"

Internet inanity began 10 years ago last week, when YouTube co-founder Jawed Karim uploaded the site's first video – a 19-second clip of his visit to the zoo

Google on the phone

Google has fingers in many pies: search, robots, self-driving cars and now, phone calls. Its new mobile network, Project Fi, launched last week. The service automatically chooses the strongest connection available – whether that's WiFi or a cell network – and routes all calls, texts and data through it. Anyone can sign up online, but for now the service only works with Google's Nexus 6 phone.

OSIRIS BIOMED

LOOK WHO'S TRENDING ON TWITTER

Last week Ed Miliband, leader of the UK Labour Party, saw teenage girls on Twitter come out to support him under the #milifandom hashtag. But do tweets and Facebook posts really translate into votes?

Twitter gives instant insights into the latest campaign events, but it has less of an impact on voters. After all, most people don't follow their local member of parliament on Twitter, and even the prime minister, David Cameron, has under a million followers. "It's where journalists pick up stories, where party activists can lobby journalists as well," says Liberal Democrat activist Mark Pack.

For coordinating party volunteers,

Facebook's tools to create groups and events are useful, says Conservative activist Anthony Ridge-Newman. "You can see who is going. If a friend is going, it might encourage you to go out and campaign."

Parties can also monitor social media to find new volunteers, says Toni Cowan-Brown of online campaigning platform NationBuilder, which parties in both the US and UK use to identify their influential Twitter followers.

"You don't win an election because you retweeted someone. You win because you continuously engage with people and get them involved," she says.

No drone zone

Technology to ground drones is taking off, finds **Chris Baraniuk**

LAST week, someone landed a drone on the roof of the Japanese prime minister's office in central Tokyo. It carried a container of sand with traces of non-harmful radioactive isotopes Caesium 134 and 137. A 40-year-old man admitted to the stunt, saying it was a protest over Japan's nuclear power programme.

How could a lone pilot land a drone right on the roof of a world leader's office? In truth, it's all too simple. Modern drones are cheap and easy to fly. They're small enough to evade traditional surveillance and many worry that this will make them attractive to terrorists and other criminals. However, it may now be possible to clip their wings.

Two weeks ago, Boston police announced this year's Boston Marathon as a "no drone zone". It might have sounded like an unenforceable plea, but the police had a trick up their sleeves. They had enlisted the help of a

company called DroneShield, which supplied acoustic sensors that can detect drones.

The sensors work by identifying the distinct noises made by motors that drive the propellers on commercially available drones. Although DroneShield did not detect any rogue aircraft at the marathon, in January the system did pick up a hobbyist drone flying close to a parade in California. Police were alerted to its presence, although it was not deemed a threat.

Takes one to catch one

Another US firm, Drone Labs, is marketing drone-detecting technology that picks up the radio waves that broadcast commands to drones. The company says this technology works well in difficult environments. "We tested it by going out to crowded areas and making sure that even with a lot of background noise we could detect

a drone," says Phil Wheat, CTO.

Using a combination of these sensing methods, Wheat claims they can detect small aerial vehicles up to half a kilometre away. Such systems can then inform operators via any number of methods, from an automated email or text message to an app notification. But what to do when a drone is in sight?

Drone Labs has partnered with firms that are investigating ways to detain detected drones. MALOU Tech in France has shown that a manually operated drone can capture another by firing a net at it. The firm is now developing an autonomous catcher drone.

These companies say they have a wide range of clients. From government agencies to sports stadia and airports – all are beginning to fight back against the intrusion of drones. Celebrities and politicians are also interested. Drones have been co-opted by paparazzi eager to get

candid shots of public figures. CJ Clark, a spokesperson for Celebrity Bodyguard Services, says he would be interested in technology that can detect the presence of drones because some of his high-profile clients have already raised the alarm.

"I have had a couple of celebrity clients in Beverly Hills and the Los Angeles area saying they've had drones flying over their pools, probably photographing them," he says. "I'm sure that

"A crashed drone found at a UK prison appeared to be delivering contraband to inmates"

the people flying these over their yards were paparazzi."

Prisons are another place where drone-detecting technologies could be of benefit. In March, staff at a prison in Bedfordshire, UK, discovered a crashed drone that appeared to be delivering contraband to inmates. Bedfordshire police, who investigated the incident, said that officers were "starting to assess" the potential of drone detection technology.

The easiest solution may come from drone manufacturers themselves. DJI, one of the biggest firms, has embedded software in its machines that prevents them from flying over hundreds of sites where drone operation is illegal, such as airports, military bases and the White House.

Steve Landells, Flight Safety Specialist at the British Airline Pilots Association, says this is a good step, although owners sometimes hack their drones and override these rules. "British pilots are definitely very concerned about the proliferation of relatively light drones," he says. "If one of those goes down an engine, it'll stop the engine, there's very little doubt about that. And as the drones get bigger and more capable, the potential if there is a mid-air collision is a lot worse." ■



Unwanted aerial delivery

Get your resumé to the top of the pile

Register your resumé on New Scientist Jobs to ensure the best employers can find you!

- ★ Be headhunted by relevant recruiters in science, research and academia
- ★ Apply for jobs quickly and easily with your saved resumé

UPLOAD CV >>>



Upload your CV today at:
NewScientistJobs.com







The planet's brain

WANT to know what a brain the size of a planet looks like? Check out the San Fernando marshes in Bahía de Cádiz Natural Park, Spain.

Covering an area of 105 square kilometres, the park blends wetlands, beaches, pine forests and reed beds, fed by the Guadalete river on one side and the Atlantic Ocean on the other. The Guadalete gets its name from an Arabic phrase meaning "river of forgetfulness", which seems appropriate for a dreamlike image such as this.

"The first time I flew over the Bay of Cádiz, I was immediately surprised at the similarity with the human brain," says photographer Cristobal Serrano.

The brain-like convolutions and fractal patterns in the marshes lie in the intertidal zone. The green areas get their colour from *Ulva* algae, also known as sea lettuce. Further inland - to the top of the picture - silt and sludge build up and in these oxygen-poor conditions, purple sulphur bacteria start to dominate.

This picture was taken at low tide, and the colours have not been manipulated. "I am a wildlife photographer," says Serrano. "My work is to show how nature sometimes can surprise us with unreal scenes." Rowan Hooper

Photographer

Cristobal Serrano

cristobalserrano.com

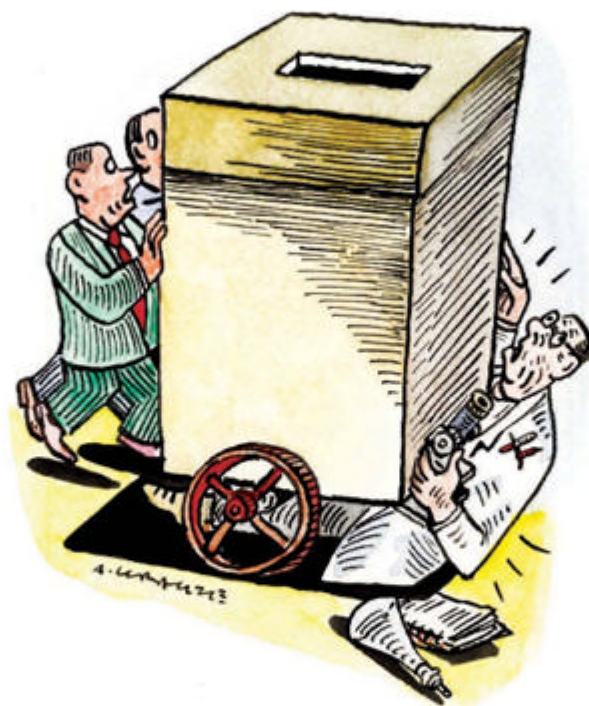
Batten down the hatches

Public-spending cuts could get much worse after the UK election. Science may be in the firing line again, warns **Jennifer Rohn**

WHAT is science for? Most will think of headline-grabbing applications: life-saving medicines, the latest gadgets and clean-energy alternatives that may one day save our planet. Others might cite vast particle colliders that reveal fundamental insights into the workings of the universe.

Few, perhaps, will consider the more prosaic economic implications of a healthy science base. But research suggests that science delivers an impressive return on investment – every pound of publicly funded science filters through to produce an ongoing return of 20 pence a year from the private sector. So in many ways, such funding should be a no-brainer.

But in 2010, Britain voted in a government intent on cutting spending to tackle the aftermath of the worst recession since the second world war. The science



budget was at risk. Despite having just 1 per cent of the global population, the UK publishes 16 per cent of the most influential research papers, and some studies put us first among all nations for research quality. With a track record of excelling on a shoestring budget, perhaps it could still do well on a little less. And when viewed alongside such emotionally charged services as hospitals and schools, how could it justify a privileged status?

The truth is that cutting investment that can foster growth made little sense, and the scientific community rallied to make this point. The result was protection of sorts: the ring-fencing and freezing of the budget at £4.6 billion in 2010. Since then, this modest pot has depreciated in real terms through inflation, with some estimating a cumulative loss of 20 per cent. The government,

Wishful thinking

Bias against women going for top science jobs is over? **Lisa Grossman** begs to differ

DISCRIMINATION against women in academic hiring has ended. Researchers Wendy Williams and Stephen Ceci claim this based on their study, which they say suggests women have a 2:1 advantage over equally qualified men in US science faculty hiring.

Yet, while 40 per cent of science and engineering PhDs went to

women in 2008, their faculty representation was low: 31 per cent of full-time doctoral posts. Why? Williams and Ceci say women avoid such jobs, possibly due to “discouraging messages about sexism in hiring” and suggest we stop those messages.

While investigating these issues is laudable, I don’t believe

Williams and Ceci’s data support their broad conclusions.

Their study involved sending descriptions of hypothetical male and female candidates of equal scholastic quality to professors to rank. But filling a faculty post involves much more than reading a biography. Lengthy interviews, site visits, talks and meetings with potential colleagues are all points at which bias can crop up.

“This study was... carried out in a way that does not resemble

“The idea we stop talking about sexism lest we deter women is wrong. Talking is the only way to tackle it”

the academic hiring process,” says Lucianne Walkowicz of the Adler Planetarium in Chicago. “When you construct an experiment that isn’t a good model of reality, you get results that are also not reflective of reality.”

It may be hard to construct an experiment that does reflect reality for academic hiring. Previous attempts looked at earlier points in the career path and came to the opposite conclusion: John got more interviews than Jane. It is also possible that in the new study, the participants figured out gender bias was being tested. The danger is the latest conclusion may make

with considerable savvy, managed to come across as “science-friendly” by drip-feeding mainly investment on infrastructure in pet projects, such as big data.

But fundamentally, science has suffered. The core budget, divvied up to keep the best labs running, has dwindled close to the point of no return. Recent analysis by Science is Vital, the campaign group I head, showed that UK public investment in research has dipped below 0.5 per cent of GDP – the worst in the G8 group of leading economies, which averages 0.8 per cent.

As the UK prepares to go to the polls again, its scientists are braced for an uncertain future. Although speaking favourably of science in general terms, neither Labour nor the Conservatives – the two leading parties – have pledged to maintain the ring fence, let alone give it the boost it desperately needs. Only the Liberal Democrats and the Greens talk of increases, but neither party is expected to win many votes.

Healthy science is vital to our economic future and prosperity: soon we will find out if the new government really gets this. ■

Jennifer Rohn is a cell biologist at University College London and the founder and chair of Science is Vital

things worse – it may give people the idea that jobs go to women not because they deserve them, but because of preferential treatment.

There is one way to interpret the study that is realistic and positive: that affirmative action, which says the under-represented candidate should get the job in cases where two candidate are equal, can work. Williams and Ceci agree with this point.

But the idea that we stop talking about sexism lest we deter female applicants is wrong. Talking about it is the only way to tackle it. ■

Lisa Grossman is *New Scientist's* physical sciences news editor

ONE MINUTE INTERVIEW

Hanging by a thread

Forensic hair analysis is badly flawed. **Peter Neufeld** persuaded the FBI to admit as much, and the exonerations have started



PROFILE

Peter Neufeld is a lawyer and co-founder of The Innocence Project, a New York-based non-profit organisation that uses DNA evidence to overturn wrongful convictions

What made the FBI reverse its position on hair analysis?

In 2010 and 2011, three men were exonerated by DNA testing in the District of Columbia. In all three cases, the primary evidence used to convict them was testimony by FBI hair examiners. When we went back and looked at the court transcripts, it was clear that the hair examiners offered scientifically invalid testimony. As a result, we approached the FBI and they agreed to review all cases where FBI analysts had declared microscopic hair matches.

Why is the technique flawed?

Just as with other forensic tests involving analysis of patterns or impressions, there are basically two questions for hair analysis: do you have a validated, reliable technique to determine a positive association between a piece of crime-scene evidence and a sample from the accused? And if you do, what is the value of that association as proof in a court of law? When we first questioned the FBI, they refused to consider the possibility that their hair microscopy methods

might be invalid. So we said, OK, let's take that off the table, but do you have any validated method for assessing the probability of an association? They didn't.

What did the FBI announce last week?

So far they have reviewed about 500 historical convictions involving hair analysis but they think there are at least 2500, and maybe as many as 4000. Of those first 500, the FBI provided hair analysis testimony in 268 cases; 96 per cent of the trial transcripts contained scientifically invalid testimony or errors by FBI agents. Thirty-three of the convicts received death sentences; nine have since been executed and five died on death row.

Does that mean the convictions are unsafe?

No. Lawyers must find out what other evidence there was to convict the defendants. In cases where hair evidence was material, the court might vacate the conviction, but in cases where it was not, it's likely they wouldn't touch it. In a subset of cases, hair evidence will still exist and the FBI has offered to do free DNA testing in such cases.

Has the review led to further exonerations?

There have been three so far, but this is just beginning. There will be many more.

Was hair analysis carried out by agencies other than the FBI?

In the 1980s and 90s the FBI trained between 500 and 1000 state and local hair examiners. They are now urging all states with examiners trained by the FBI to conduct their own reviews.

Forensic science seems to be unravelling. Are other techniques likely to face scrutiny?

What you see with hair is illustrative of a much larger problem. A lot of the methods traditionally utilised by forensic laboratories and police departments were never validated, violating a fundamental principle of the scientific method. I think we will be seeing more of this kind of review. Ultimately, we will be better off for it.

Interview by Linda Geddes

Rocket man

Fighter jets and moon missions set a young **David Mackay** on course to fly spaceplanes for Virgin – but tragedy is always just around the corner

What inspired you to take to the skies?

When I was 6 my family moved to a remote village in the north of Scotland. Almost daily we'd see jet aircraft flying fast and low. It looked incredibly exciting. Then the Apollo moon missions were shown by the BBC and that captured my imagination. I found out those astronauts were ex-military test pilots and so I came up with this scheme to join the Royal Air Force, become a test pilot and then maybe an astronaut. That sounded like a fantastic career path. I was aware that the UK had no manned space programme but I just hoped that something would work out.

How did that pan out for you?

I joined the air force and ended up flying Harriers at low altitude – a very exciting and demanding form of flying. As soon as I had sufficient experience I became a test pilot.

So how did you end up at Virgin Galactic, aiming to take people to the edge of space?

I came to the point where if I wanted to stay in the RAF, I'd have to do more and more managerial work. I wasn't ready to give up flying, so reluctantly I decided to leave. I was fortunate to get a job with Virgin Atlantic and three years later I was a captaining 747s.

In 2003, Virgin Atlantic announced it was going to sponsor an aircraft called GlobalFlyer, built by Scaled Composites in Mojave. I came out in 2004 to look at GlobalFlyer but we were aware that the company also had a spaceship, SpaceShipOne. We got invited to fly the simulator and talk to engineers and company founder Burt Rutan about it.

I thought it was a remarkable vehicle with a lot of potential. Those ideas went back to Richard Branson, and Virgin Galactic took off after that. They decided they wanted a test pilot and I was asked to join.

SpaceShipTwo is carried into the sky by another plane, White Knight Two, before being launched into space. How does that work?

The climb up to launch altitude takes about 50 minutes and gets very close to 50,000 feet, so it's already quite a spectacular view. The release is a dynamic affair. For the best part of an hour you've been underneath this four-engine aircraft but, as you release, it suddenly goes completely quiet for a couple of seconds. The two vehicles spring apart quite dramatically – it's like going over the top of a sharp roller coaster. About 3 seconds after release the rocket motor is lit.

You've only flown once with the rocket firing. How did it feel?

It's an incredible sensation, almost like a magic carpet ride. It's not an abrupt kick in the pants, but it does come up to full thrust very rapidly, over about 0.7 seconds. From there you're accelerating at about 3g. It's a remarkable push in the back.

Once we're through the sound barrier we start pitching the vehicle up into the vertical. That takes 20 seconds or so, accelerating all the time at about 3g. On that test we reached Mach 1.4.

I had prepared myself for what I thought the sensations were going to be like and so I wasn't surprised, except by how quiet the motor was: from the ground they're incredibly noisy, but in the vehicle all the noise is behind you.



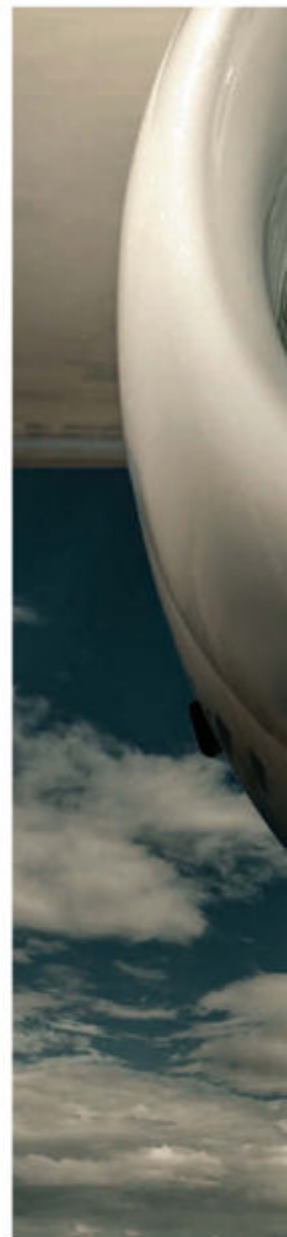
PROFILE

David Mackay was a test pilot for the Royal Air Force, captained Boeing 747s for Virgin Atlantic and is now chief pilot for Virgin Galactic based in Mojave, California

Joyride: come on up to the edge of space, the view is lovely

How does the craft handle?

The controls are two-handed, like the reins of a horse, so it almost feels like you are holding on to a wild animal, but that's not accurate because it's so smooth. Holding on to this thing and controlling it is a wonderful ride. When the motor shut down, one of the hardest things was not to come out with a string of expletives that I might regret later. Virgin Galactic is great at selling the weightless experience and the views from space, and those will be remarkable, but I think the actual rocket ride up there is going to be pretty sensational.





How was the view up there?

On that flight we got up to 71,000 feet. Several people asked me afterwards what the view was like. I'm afraid I can't tell you because we were so busy running checks that I didn't have time to look out the window.

Last October, SpaceShipTwo broke up and crashed, killing test pilot Michael Alsbury and injuring his co-pilot...

It was a tragic day. We lost a friend, a colleague and a lovely person. We feel great sympathy for his friends and family. But I am sure that Mike would not want this project to end.

I think we're more determined than ever. To give up right now would be an insult, I think, to all the work that's been done, and the sacrifices that people have made.

How will you feel when you climb into the new SpaceShipTwo?

I will only go on that flight if I'm completely confident that it's going to be safe and we're going to be able to do what we set out to do. Everybody feels like that: nobody's putting us under pressure to get this done quickly. In my time in the RAF I lost a lot of friends and it's something that you have to deal with. You

learn from other people's mistakes and that's how progress has been made throughout the history of aviation.

What do you say to people who dismiss Virgin Galactic as joyrides for the rich?

I don't see it like that. Yes, we have lots of wealthy customers, but we also have a lot of people who have made considerable sacrifices to buy a ticket. I think a lot of our customers are similar to a lot of people who work here;

"To give up now would be an insult to all the sacrifices that have been made"

they're really enthusiastic about what we're doing and they want to be invested in this endeavour. A lot of them want to see private space flights succeed and this is one way of helping.

How long will it be until the new SpaceShipTwo is in the air?

We're reluctant to say we're going to fly on a given date, because people start to say, why haven't you done it? But we should be ready to start the test programme this year. And once this one is complete, or pretty close, the plan is to build another one.

Looks like your dream of being an astronaut is closer than ever

I've got no doubt it's going to happen. We've got some great vehicles, a great motor, fantastic people and a very enthusiastic passenger corps who I think are in for an absolute treat. I thoroughly believe that when you come back the first thing you'll want to do is go and do it again. I view it as the start of something important in the development of commercial space travel.

If NASA were to offer you a trip to Mars, how would you react?

I'd love to go to Mars. It's a very intriguing planet with some sensational geographical features – Olympus Mons and perhaps the largest canyon in the solar system. I think there are some challenges with healthily surviving a trip so I'd want to know more about that.

What if it was a one-way mission?

No. To be honest, I love life too much. I always want to come back. ■

Interview by Sean O'Neill

CHRIS GREMAN





SPECIAL ISSUE

HUMAN UNIVERSE

On Earth, we rule the roost: *Homo sapiens* is the planet's most intelligent, influential and destructive species. We are so dominant that we are considering naming an entire geological epoch after ourselves, the Anthropocene.

But there's a whole universe out there. How do we measure up by that cosmic yardstick?

Are we really the only intelligence? What, if anything, does the rest of the universe know about us? Could we, or should we, spread to other planets? What, if anything, will our lasting legacy be? Over the next 8 pages we explore humanity's place in the universe.

- 1 Was the universe made for us?
- 2 Does consciousness create reality?
- 3 Can we understand everything?
- 4 Could we destroy the universe?
- 5 Does the cosmos know we're here?
- 6 Could we colonise the stars?
- 7 Can we engineer the universe?
- 8 Could we become gods?



1 WAS THE UNIVERSE MADE FOR US?

For much of our existence on Earth, we humans thought of ourselves as a pretty big deal. Then along came science and taught us how utterly insignificant we are. We aren't the centre of the universe. We aren't special. We are just a species of ape living on a smallish planet orbiting an unremarkable star in one galaxy among billions in a universe that had been around for 13.8 billion years without us.

But maybe we were too hasty to write ourselves off. There is a sense in which we are still the centre of the universe.

Science also teaches us that the laws of physics are ridiculously, almost unbelievably, "fine-tuned" for you and me. Take the electromagnetic force. It has a value that is perfectly set for getting stars to bind protons and neutron to create carbon – the building block of life as we know it. Or the strong nuclear force, which binds the insides of protons and neutrons. If it were even a tiny bit stronger, the whole world would be made of hydrogen; if it were weaker, there would be no hydrogen at all. In either case, life as we know it wouldn't be possible. Even the amount of energy contained in empty space seems perfectly set to allow intelligent life to flourish. That's not all. All told, about 12 parameters have been identified as being just right for life.

Why is the universe so perfect? Most physicists now argue that in some sense, it could not have been otherwise. That reasoning has given rise to several different answers known as "anthropic principles".

One end of the spectrum puts us truly back in the centre. This extreme anthropic principle posits that the universe is so perfect that it must have been made for us, either by an intelligent creator or, more likely, because of some fundamental feature of the cosmos that drives it towards intelligent life. In his book *The Goldilocks Enigma*, Paul Davies, a cosmologist at Arizona State University, tentatively suggests the possibility that life could be a law of nature. He calls it the "life principle", although he admits it is verging on the theological.

Most physicists have no time for ideas like this. "To say that this is all for us? That is just completely bizarre," says Sean Carroll, a cosmologist at the California Institute of Technology in Pasadena.

Perhaps, then, it is the other way round: according to another formulation of the anthropic principle, the universe only exists because we do. We conjure it up with our consciousness (see right).

Some less mind-bending versions of the principle are also available. They try to explain why the universe would appear perfectly made for us, even if it isn't. In a nutshell, this weak anthropic principle says that given that we are around to observe the universe, it simply has to allow for our existence.

This is often taken to imply that there are other regions of the universe – or even other universes – where physical laws and constants are different. So asking why things are this way amounts to asking why we are in this region. In that case, the anthropic principle is merely pointing out that places that are hospitable to our kind of life are the only places we can possibly be.

This line of reasoning has been bolstered by the possible existence of a multiverse, versions of which emerge from both quantum mechanics and standard cosmology. With lots of other universes, each with their own physical constants and laws, the mystery of our own fine-tuned universe evaporates. We can only be in one that is fine-tuned for carbon-based life.

But even if this version of the anthropic principle explains fine-tuning, it still restores us to some of our former (self-appointed) glory by putting human observers firmly back into our description of the cosmos. "If you want to explain the universe that we see, the very fact that we are seeing it is part of that explanation," says Davies. "It is a bit of a U-turn in the history of science that has been removing the observer from the picture altogether." Welcome back.

Michael Slezak



SAM CHIVERS



2

DOES CONSCIOUSNESS CREATE REALITY?

Samuel Johnson thought the idea was so preposterous that kicking a rock was enough to silence discussion. "I refute it thus," he cried as his foot rebounded from reality. Had he known about quantum mechanics, he might have spared himself the stubbed toe.

Johnson was responding to Bishop Berkeley, a philosopher who argued that the world was a figment of our minds. Could he have been right?

With its multiverses and cats both alive and dead, quantum mechanics is certainly weird. But some physicists have proposed that reality is even stranger: the universe only becomes real when we look at it.

This version of the anthropic principle (see left) - known as the participatory universe - was first put forward by John Archibald Wheeler, a heavyweight of 20th-century physics. He likened what we call reality to an elaborate papier mâché construction supported by a few iron posts. When we make a quantum measurement, we hammer one of those posts into the ground. Everything else is imagination and theory.

For Wheeler, however, making a quantum measurement not only gives us an objective fix on things but changes the course of the universe by forcing a single outcome from many possible ones. In the famous double-slit experiment, for example, light is observed to behave either as a particle or as a wave, depending on the set-up. The most baffling thing is that photons seem to "know" how and when to switch. But this assumes that a photon has a physical form before we observe it. Wheeler asked: what if it doesn't? What if it takes one only at the moment we look?

Even the past may not yet be fixed. Wheeler proposed a cosmic version of the double-slit experiment, in which

light from a quasar a billion light years away reaches us by passing around a galaxy that distorts its path, producing two images, one on either side of the galaxy. By pointing a telescope at each, observers would see photons travelling one of two routes as particles. But by arranging mirrors so that photons from both routes hit a detector at the same time, they would see light arrive as a wave. This time, the act of observation reaches across time to change the nature of the light leaving the quasar a billion years ago.

For Wheeler, this meant the universe couldn't really exist in any physical sense - even in the past - until we measure it. And what we do in the present affects what happened in the past - in principle, all the way back to the origins of the universe. If he is right, then to all intents and purposes the universe didn't exist until we and other conscious entities started observing it.

Sound crazy? Then try this one on for size. Another interpretation of quantum mechanics is Hugh Everett's many worlds hypothesis, which posits that everything that could happen has and does, in an infinite number of universes. Every time you make a decision, the universe splits in two, with you in one branch and an alternative you in the other, living the other possibility. The universe you occupy is, in some sense, an individual universe of your own making.

This idea is enough to give anyone a reality check. "My natural inclination is to be a realist," says Chris Timpson, a philosopher of physics at the University of Oxford. "But if you're going to be a realist about the quantum world then you're left with a world that's very peculiar." So peculiar, in fact, that the idea that it only exists because of us seems almost sensible.

Douglas Heaven



CAN WE UNDERSTAND EVERYTHING?

It took 3.8 billion years, but we got there in the end. For most of the history of life on Earth, life was pretty dull. Then humans evolved, and things got interesting.

One of the defining features of our species is our ability to make connections. From birth, we can't help but recognise patterns. Arrangements of dark and light resolve into faces, sounds into voices. Some of these patterns become more abstract rules about the world – day follows night, things fall down. They allow us to draw inferences about things: a stone falls, therefore an apple will too.

What goes for us individually applies to our species as well. The history of science is the history of seeing ever deeper connections between apparently unrelated phenomena. Newton recognised that the same force that causes an apple to fall also keeps the moon in orbit: gravity. Faraday and Maxwell showed that electricity and magnetism were two sides of the same coin; electromagnetism itself was later united with the weak nuclear force, responsible for things like beta decay.

Each of these unifications reduces the number of separate physical theories required to understand the universe, leading many to believe that it may eventually be possible to unify all of them into a single theory – a much-vaunted theory of everything.

Is that a realistic prospect? Could we, a species of ape with a brain evolved for survival on the African savannah, really figure out the whole thing?

"We've understood an enormous amount about how the world works in an extremely short period of time, cosmically speaking," says Sean

Carroll, an astrophysicist at the California Institute of Technology in Pasadena. A century ago, we didn't know that other galaxies existed, or that the universe is expanding, he says. And that's just the start. In the past 100 years we have discovered most of quantum mechanics, a whole zoo of new particles, the existence of dark matter and dark energy – and we have woven these and other empirical observations into a series of very successful theories about how the universe works. "At this rate, we have every reason to think we can understand it all someday," says Carroll.

Or maybe not. Chimps, smart as they are compared with, say, tortoises, will never grasp quantum theory, or even recognise the need for such a theory. And although we are smarter than chimps, why shouldn't there be concepts that are too big or too complex for our brains to handle? In some senses, such unknowables do exist. Turbulent fluids, stock markets, crowd dynamics, even the functioning

of our own brains are all impossible for us to fathom without the help of computer models.

Even if we are capable of understanding everything, there's much work to be done. Our two most successful physical theories – general relativity, which deals with very large things, and quantum mechanics, which deals with very small ones – are maddeningly hard to unify.

Similarly, we know of four fundamental physical forces: electromagnetic, weak nuclear, strong nuclear and gravity. Three of these forces play nicely with each other in the form of the standard model, our best description of how fundamental particles interact. The odd one out? Gravity.

Unifying gravity and the standard model would be a huge step towards a theory of everything. Our best shot so far is string theory, which recasts all phenomena as the result of tiny vibrating strings interacting with each other. The problem is, we don't have a good way to test it. And without

verification by experiment, how can we say we really "understand" it?

Nonetheless, there's no reason to think we won't eventually be able to test our theories and understand the cosmos, says Peter Woit, a mathematician at Columbia University in New York.

So what happens when we do fully understand the cosmos? If knowledge is power, how powerful will it make us? Woit says there's an outside possibility that some insight will lead to a *Star Trek* future of warp drives and wormholes. But it could just as easily show why these things are impossible.

A theory of everything could also have profound cultural impacts, perhaps telling us that we are, after all, the centre of the universe (see page 32), or a holographic projection from the edge of it. What is sure is that we will keep on striving. "The point of searching for a theory of everything isn't to do things," says Carroll. "It's to understand how the world works. Discovery is its own reward."

MacGregor Campbell



4

COULD WE DESTROY THE UNIVERSE?

With great power comes great responsibility. As our grip on Earth grows ever tighter, so does the possibility that we could destroy it, or at least ourselves. But the prospect pales into insignificance when you consider that we may have the power to do something even worse.

We could destroy the universe.

Remember the outcry when CERN was getting ready to start smashing particles together in its Large Hadron Collider? A few doomsayers warned that it might be opening the door to the apocalypse.

This existential angst was triggered by the prospect of protons colliding at extremely high energies. Einstein's general theory of relativity suggests that concentrating this kind of energy in a volume smaller than an atom might distort space and time enough to tear a hole in the fabric of the universe. This "mini black hole" could rapidly expand to engulf the entire cosmos.

CERN took the possibility seriously enough to carry out the ultimate workplace health and safety assessment. In 2008, it declared the disaster scenario virtually impossible. That assessment still stands, even though the LHC is now powering up to almost double its original energy.

We aren't completely off the hook, however. That's because the Higgs boson, discovered in the LHC in 2012, has given us reason to believe we might destroy the universe in a completely different way.

This danger was first pointed out in 2008 by physicists Lawrence Krauss and James Dent, both then at Case Western Reserve University in Cleveland, Ohio. The problem, they said, is that the universe is governed by the rules of quantum physics, where observations of a system can affect its state (see page 33).

The notion might be familiar to you in the form of Schrödinger's cat. In this thought experiment, a cat is placed in a sealed box with a vial of deadly poison that will be cracked open if a quantum event occurs: the radioactive decay of an atom. According to standard interpretations of quantum theory, as long as the box remains sealed, the cat is



both alive and dead. It is the act of opening the box and observing the state of the cat that determines whether the radioactive decay occurs. In other words, human observation changes the state of the system.

Krauss and Dent suggested that something similar applies to the universe. It is theoretically possible to write down a quantum state for the cosmos. This moves between different states, just like the radioactive atom in the Schrödinger's cat experiment, and can be similarly affected – in theory – by human observations.

An observation of something that is a property of the whole cosmos, such as the dark energy thought to be accelerating the universe's expansion, might cause a sudden shift from being in a mixture of two states to being in one definite state. So looking at a supernova could be enough to alter the overall quantum state of the universe. The result might just "reset" the universe's state, moving it back to where it was a few moments before. But there is a remote possibility of catastrophe.

This is because we are living in what physicists call a false vacuum – essentially an unstable configuration of space and time. That means the universe's quantum state is slowly decaying towards a more stable one. However, an observation could tip it into that state abruptly. The universe would suddenly cease to exist, then reappear as a new, more stable cosmos – without us in it.

Not surprisingly, this was a controversial idea when first raised, not least because we didn't know whether we were living in a false vacuum. However, some of the properties of the Higgs boson tell us that we almost certainly are. "The discovery makes the issues we discussed more relevant," says Krauss, who is now based at Arizona State University.

We don't know for sure that observing the cosmos can affect its quantum state. If it does, we really could precipitate our universe's demise. But like the LHC black hole scare, it isn't something that should keep us awake at night; Krauss says it was just a thought experiment, not a proof of peril.

Michael Brooks



DOES THE COSMOS KNOW WE'RE HERE?

To the best of our knowledge we are alone in the universe. But if we're not, do the aliens know that they aren't alone? And if they know we exist, how much do they know about us?

It largely depends on who they are and where they live. If they inhabit planets orbiting nearby stars – up to a few dozen light years away – and are of comparable intelligence and technological development to us, they might know we are here, thanks to various messages we have deliberately beamed to an assumed interstellar audience. But that also means their knowledge of us is selective at best, confined to the Beatles, Doritos, theremins and a few other trivialities.

If our neighbours are more advanced – enough to have blanketed their moons in receivers, for instance – they might have been watching the weak TV signals that have beamed from Earth at the speed of light since transmissions really took off after the second world war. Assuming they managed the relatively simple task of decoding the signal, they would know a lot about us: what we look like, how we behave and relate to one another, our breeding habits, culture, history – and predilection for watching trash.

There probably are a few Earth-like exoplanets that are close enough for our broadcasts to have reached them. But the chances of advanced life being on one them at just the right time to listen in is minuscule. And if they are there, they have done a good job of hiding their presence from us.

Beyond such relatively limited distances, the odds of advanced life could be higher, purely on the basis of the numbers. There are several hundred billion stars in our galaxy, a million of them within 1000 light years. But our artificial signals haven't had time to reach them yet. Could civilisations at these distances

know anything about us?

Technically it is feasible to conceive of telescopes capable of gathering information from vast distances, although it would require a truly astronomical aperture to see anything in detail. One way around this is to use a massive object, like a star or a black hole, as a giant gravitational lens, by seeing how it bends light. If we used our sun in this way, which is technically possible although horrendously complicated and expensive, we could make out road networks or detect street lighting on the surfaces of nearby exoplanets, should they exist.

For a much more advanced society, it is conceivable that our ancestors' burgeoning imprint on Earth could have been observed from hundreds or thousands of light years away – although the farther away they are, the less of our history is accessible to them.

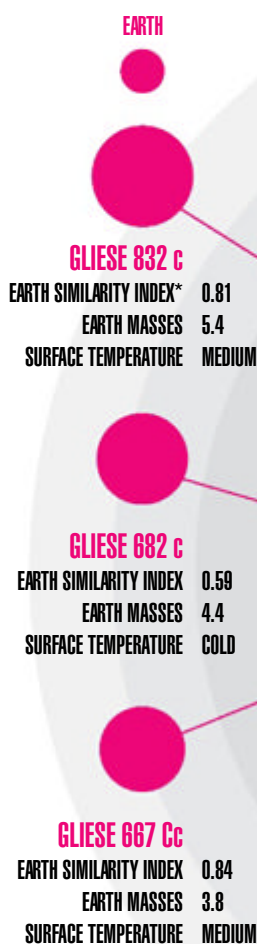
What about societies even more distant? Given our current ability to detect exoplanets, it isn't a huge leap to imagine that civilisations millions of light years from Earth know that our rocky planet is here, in the habitable zone of a yellow dwarf star in an arm of a spiral galaxy. Our planet's 2-billion-year-old oxygen signature may have been picked up along with other spectral hints of ancient life. But the existence of intelligent life would be inaccessible to them.

"If I were an alien society just 100 years more advanced than us, my astronomy text books would surely contain huge tables of habitable worlds. Earth would be among them," says Seth Shostak, director of the SETI Institute in California. Although they would call it something different, perhaps as functional and unglamorous as the names we give to the habitable worlds we know about. Greetings planet KOI-3010.01, we come in peace...

Jon White

HOME FROM HOME

Potentially habitable rocky planets within 50 light years of our solar system



*Earth Similarity Index is a scale from 0 (not similar to Earth) to 1 (exactly like Earth) based on the planet's radius, density, surface temperature and escape velocity. It is not a measure of habitability. Mars has an ESI of 0.64

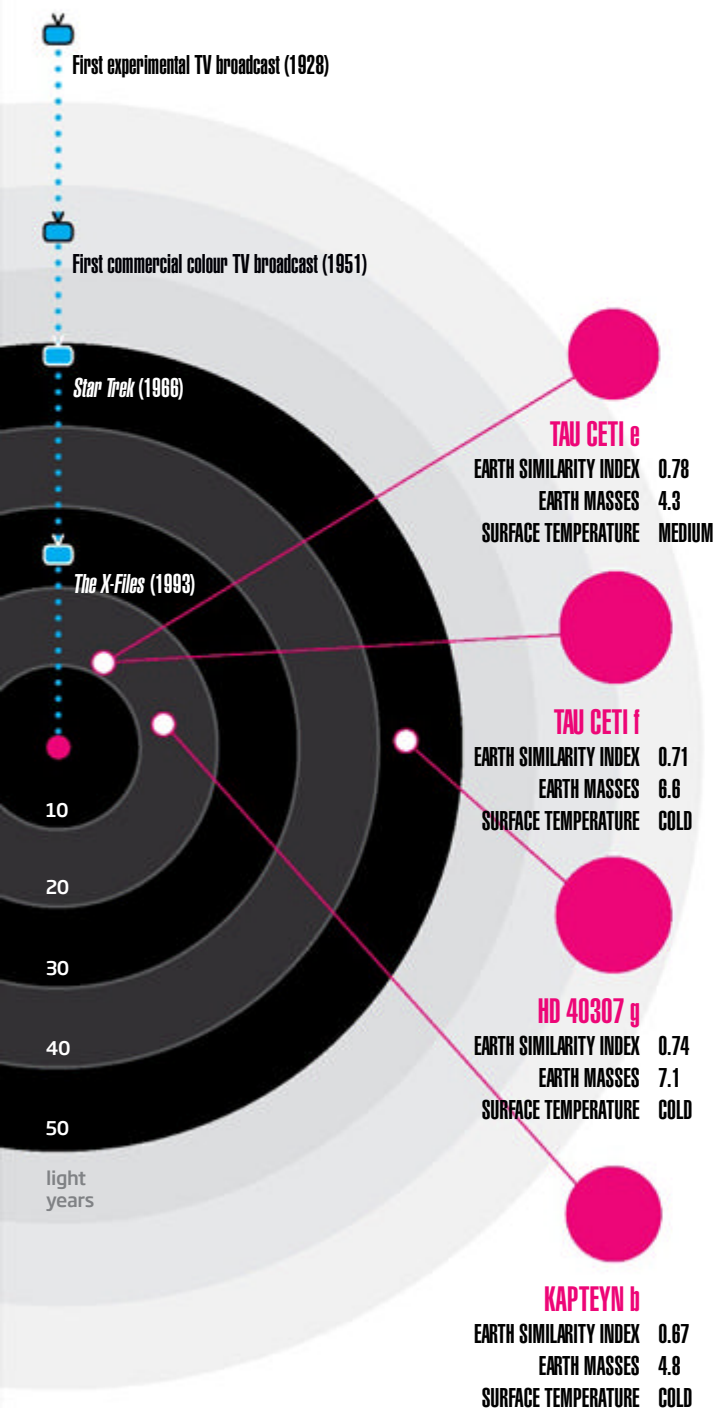
Earth masses represented by two dimensional surface area.

Positions of the dots represent distance from the sun on the plane of Earth's equator. They don't represent distances between exoplanets



BROADCASTING TO THE STARS

TV signals from Earth are travelling outwards at light speed. Even broadcasts from as recently as 1973 have reached and gone beyond these potentially habitable planets.



COULD WE COLONISE THE STARS?

It's fun to speculate about aliens (see left). But what if there are no aliens? It's been 65 years since Enrico Fermi first pointed out our solitude. Fermi estimated that it would take an advanced technological civilisation 10 million years or so to fill the galaxy with its spawn. Our galaxy is 10,000 times older than that. Where is everybody?

It's not as though we haven't been looking. Not for long, perhaps, and not very hard, but even a crude estimate suggests there should be other advanced civilisations capable of signalling over interstellar distances. And yet - nothing.

So what if we really are alone, or so isolated as to amount to the same thing? "If we think we are the only life in the universe, we have a huge responsibility to spread life to the stars," says Anders Sandberg of the University of Oxford's Future of Humanity Institute. "If we are the only intelligence, we may have an almost equal responsibility to spread that, too."

NASA astronomer David Grinspoon agrees, although he hasn't given up on finding ET yet. "We have these powers that no other species has had before," he says. "If we are it, if we are the best the universe has got, if we are the universe's sole repository of intelligence and wisdom and scientific insight and technology, it ups the ante quite a bit. We have a responsibility to preserve our civilisation."

It won't be easy. First, we need to decide where to boldly go. We don't know if humans can survive for any meaningful length of time anywhere except the surface of Earth. "Nowhere in our solar system offers an environment even as clement as the Antarctic or the top of Everest," says the UK's Astronomer Royal Martin Rees. But some pioneers aim to give it a go anyway. Billionaire inventor Elon

Musk is aiming to establish a self-sustaining colony on Mars in the next 50 years. "By 2100, groups of pioneers may have established bases entirely independent from Earth," Rees says.

Second, we are going to need some serious propulsion power but we don't yet know what that will look like. Third, we have to have some way to deal with interstellar dust, which could create catastrophic collisions with our craft at the speeds we would need to attain. Fourth, we would need some kind of artificial gravity onboard, otherwise the crew will suffer massive, possibly fatal, health issues.

There will undoubtedly be many more obstacles that we have yet to confront or even imagine. But Sandberg and others are optimistic we can overcome them.

Even if we can't, we could play the longer game and attempt to seed the galaxy with life via "directed panspermia". The basic idea is to launch microorganisms into space in the hope that they will crash-land on a planet or moon suitable for life, and eventually evolve into a self-aware, intelligent species.

Science fiction author Charlie Stross suggests isolating spore-forming archaea and photosynthetic bacteria that can survive for long periods in the harshest of environments. "Put them on rockets and fire them out of the solar system," he says. "Almost all will perish, but if you launch a hundred tonnes of spores every year for a century, maybe sooner or later something will work."

There would be no real payback for us, except perhaps returning a favour. Life on Earth may have started by directed panspermia. If so, our ultimate purpose may be to pass it on again, like a chain letter through the cosmos.

Michael Brooks

7 CAN WE ENGINEER THE UNIVERSE?

Humans have begun to transform the Earth. We have built cities, transport networks and power stations, and sprinkled the skies with satellites. If we extrapolate this ability to engineer our own environment – for living space, travel, energy and communications – where does it lead us? Could we transform space too?

Predicting the far future is a fool's game.

So let's take the usual dodge and say: unless something is forbidden by known physics, it will be done. Eventually.

Before we start, let's invent two things: self-repairing AI supervisors that can direct projects lasting many millennia; and vehicles that can reach close to the speed of light, maybe riding on laser beams or driven by miniature black holes – which according to recent calculations by physicists at Kansas State University may be possible.

Thus tooled up, we could hop from solar system to solar system, sweeping across the galaxy in 10 million years or so, and then out into our local supercluster of galaxies. So the potential building site is quite spacious.

Such a civilisation would consume lots of energy, and that is where our engineering may be most conspicuous. One option will be to plug in to local power sources, such as harnessing starlight with orbiting solar power stations. As demand for power grows, lots of these could be arranged to obscure a star completely, forming a closed "Dyson sphere", named after physicist Freeman Dyson, who pointed out that technological civilisations tend to use ever-escalating quantities of energy.

If we built one we would darken the sun and leave a vast archaeological ruin in the event of our demise. Today, Earthly astronomers are looking for the darkness cast by alien engineering on this scale.

With this level of technology we could even move stars around, albeit slowly. The simplest way would be to place a mirror on one side of the star to reflect some of its light into a beam, producing thrust in the opposite direction. Or the energy from a Dyson sphere could power ion engines to move the star a bit faster. We might use such a stellar engine to coast away



from a predicted supernova, or to take two small dim stars and smash them together to make a brighter power plant.

If wrangling mere stars seems humdrum, how about harnessing the power of a supermassive black hole? We could catch the radiation from its accretion disk, or suck energy out of its spin. A spinning hole drags space-time around it in a region known as the ergosphere, which we could exploit in at least two ways. Roger Penrose of the University of Oxford has suggested using it to accelerate a stream of matter to high speeds, whereas University of Cambridge physicists Roger Blandford and Roman Znajek have devised a way to turn it into an electromagnetic dynamo. These could be the basis of a power plant a billion times as powerful as a Dyson sphere. It would have to be the size of our solar system, at least.

Even that might not be the limit of our ambition. Our quest to understand the cosmos (see page 34) may lead us to build the ultimate particle accelerator, capable of reaching the immense energy where all forces are unified and the fundamental nature of space-time is finally revealed.

Brian Lacki at the Institute for Advanced Study in Princeton, New Jersey, has worked out some of the properties of this machine. One of them is immense size: to be able to boost particles to the required energies it would have to stretch at least a hundred times the distance from the sun to Pluto.

This is just a lower limit, but making it even bigger should be possible. Such a long, thin object can be extended indefinitely without producing overwhelming gravitational stress, so we might be able to build a tower out to Orion and beyond.



NASA/ESA/SC/CXC/ST/SCI

At the limits of imaginable technology, we might even end up tinkering with the fate of the cosmos. If our hunger for power isn't satisfied by stars and supermassive black holes, then we might learn to create microscopic black holes and feed them with dust. This could unlock the mass-energy of inert matter, turning it into hot Hawking radiation that could be used to drive our interstellar industry.

According to calculations by S. Jay Olson of the University of Queensland in Australia, this could change the future of everything. With civilisation spreading through space at close to the speed of light, it would fill the cosmos with waste heat and so change its physical properties. The conversion of matter to radiation would even slow down the expansion of space a little, which puts our petty meddling with Earth into perspective. **Stephen Battersby**



COULD WE BECOME GODS?

We are a curious species, and our curiosity has led to some interesting ideas about our place in the universe: gods, evolution, quantum consciousness and the multiverse.

But perhaps the most curious of all is the idea that the universe isn't real, and we live in a computer simulation created by a superior intelligence. In fact, according to Nick Bostrom, the philosopher who developed the idea, this is the most likely explanation for our existence.

Whatever the plausibility of this claim, it begs a tantalising question: could we ever create such a simulation? Could we become the gods of an artificial universe inhabited by creatures so smart they are able to question their own place in their universe?

The first requirement would be to create artificial intelligence that can carry out the same range of intellectual tasks as a human. According to cognitive roboticist Murray Shanahan of Imperial College London, there's no reason to think we can't, although it could take decades. "There's nothing magical about the brain; it doesn't transcend physics. So of course it is possible to build a physical entity that can do anything we can do," he says.

But it will take more than brute computing power to build a brain. "What matters is structure, the pattern, the connections," says Peter Bentley at University College London, and we don't yet have a detailed enough blueprint of the brain to reproduce that. But the European Union's 10-year Human Brain Project is working on it.

In the meantime, simpler brains are already being simulated. A project called OpenWorm is putting the finishing touches to a virtual version of the tiny nematode worm *Caenorhabditis elegans*, including its rudimentary nervous system of 302 neurons. This relative simplicity has allowed the connections between all its cells and its entire repertoire of behaviours to be mapped and simulated.

Is this taking us towards truly intelligent,

life-like brain simulation? "It could be a first step in that direction," says Stephen Larson, who runs the OpenWorm collaboration from San Diego, California.

But a virtual brain by itself isn't going to learn anything, let alone question its place in its world. It needs a range of senses and an environment with which to interact. Current technology has a long way to go. "We need a supercomputer just to compute the electron cloud around one atom. And there's quite a lot of atoms in our world," says Bentley. Fortunately, the goal isn't to recreate everything we know about the universe, but something rich enough for simulated beings to get their digital teeth into. We may also decide to bury some fossils in the simulated earth, to throw our creations off our scent.

If and when we get there, how should we treat such creations? What kind of gods would we be? Capricious ones, perhaps: there are web pages devoted to sadistic ways to kill characters in *The Sims* video games.

But Old Testament-style wrath could give way to a gentler approach if we appreciated what we have created. "We've got to get away from the idea that computer software equals unreal," says Bentley. "Software is a bunch of electrons - a type of lepton - whizzing about in specific patterns within the electronics of your computer. And what are you? A bunch of quarks and leptons whizzing about in specific patterns."

Bostrom, at the University of Oxford, agrees. "I think we should try to treat all sentient creatures compassionately, whether they are digital or not," he says.

Before you get dizzy with the prospect of omnipotence, bear in mind where we started: there's a better-than-evens chance that you and everything you know is already part of a simulation. That wouldn't stop us creating a simulation within our simulation, and so on ad infinitum. But it puts a different perspective on our place in the grand scheme of things.

Sean O'Neill



THE IMPERSONATORS

It isn't just impressive when birds mimic sounds:
it can be a matter of life and death, finds
Daniel Cossins

GERALD BORGIA has spent 20 years spying on the spectacular wooing techniques of male bowerbirds. He has watched them construct intricate bowers, and adorn these with decorations gathered from the forest. He has marvelled at their flawless vocal impressions of laughing kookaburras and honeyeaters, cats' meows and car engines. But even Borgia was left slack-jawed by what he caught on tape during one field trip to the remote highlands of Papua New Guinea.

Poring over hundreds of hours of footage back in his lab at the University of Maryland in College Park, Borgia came across a male streaked bowerbird belting out an extraordinary soundscape. It started with dogs barking and people chatting as they traipsed through the forest slashing at foliage, and continued with the sounds of machete strikes and a falling tree, complete with the rustle and shake of leaves and the great crash of it hitting the ground. "I played it back again and again because I couldn't believe it," says Borgia. "This bird was mimicking an entire audio scene with the most astonishing accuracy. I was amazed... shocked. It's by far the most impressive piece of vocal mimicry I've ever heard."

The streaked bowerbird may be a virtuoso, but it is not the only bird with such talents. The branches of the avian family tree occupied by perching birds, including songbirds, are bristling with expert impersonators. These range from familiar species such as the northern mockingbird – whose Latin name translates as "many-tongued mimic" – to exotic ones like the superb lyrebird that put in a star turn in David Attenborough's *The Life of Birds*, with its impressions of an old-style camera shutter and a chainsaw.

These flabbergasting feats have been celebrated for centuries, but only now have scientists begun to figure out why birds do impressions. Their discoveries are overhauling the idea that avian impersonations are a useless by-product of the vocal learning process. Instead, they suggest that mimicry can pay off in a variety of ingenious ways. In other words, the ability to mimic can be an evolutionary adaptation that increases an individual's chances of passing on its genes.

Seductive routines

Until a few years ago, there was precious little evidence that pirating sounds was profitable. Some people believed that birds mistakenly copy other species when learning the calls of their own kind. Another idea was that mimicry was an efficient way to develop a large repertoire of songs, something which helps males win mates. "But that doesn't fully explain why so much vocal mimicry is so accurate," says Laura Kelley at the University of Cambridge. "For mimicry to be as faithful as we know it is, you might expect some selection pressure for accuracy."

In 2007, Borgia and colleagues published the first compelling evidence that there is. The male satin bowerbird is a talented mimic with lustrous blue-black plumage that struts its stuff in the tropical forests of Australia. Having watched hundreds of these seductive shows, Borgia wanted to find out whether females judge males by the accuracy of their impersonations. He recorded 123 courtship displays at Wallaby Creek in New South Wales, during which each male mimicked five different bird species, including the kookaburra and Lewin's honeyeater. Then he

compared visual read-outs of these songs to those of the birds being imitated. Sure enough, females preferred males who produced highly accurate impersonations. In fact, the accuracy and range of vocal mimicry were more closely correlated with mating success than bower structure or number of decorations.

"The female is basically saying, 'you did the kookaburra better than your rivals, so I'm picking you,'" says Anastasia Dalziel at Cornell University in Ithaca, New York, who has studied vocal mimicry in superb lyrebirds. This suggests that mimetic accuracy provides females with signals about a male's quality, although it's hard to know exactly how this works. It might be that learning and copying the songs of other species is a cognitive challenge, so the best mimics are also the smartest birds and therefore the most desirable mates. Or it might simply indicate maturity, with older males having had longer to perfect their imitations.

So being a good mimic can increase a male's ability to win a mate. But that is not the only advantage: many birds produce copycat calls when attacked, and a clutch of studies has now demonstrated that doing so helps some to escape predators.

The greater racket-tailed drongo, which hangs out in mixed-species flocks across Asia, mimics alarm calls produced by its neighbours when attacked. Last year, Eben Goodale, now at Guangxi University in Nanning, China, wanted to see how this affects the behaviour of those neighbours. Working in Sri Lanka, he recorded drongos' copycat alarm calls and played them back to orange-billed warblers and ashy-headed laughing-thrushes. Both species reacted with mobbing behaviour and by fleeing, and they ➤

WHO'S A CLEVER BIRD?

ALEX THE AFRICAN GREY PARROT

SPECIAL SKILL: Language

Alex knew 150 English words, and seemed to understand what they meant. He could describe 50 objects by colour, shape and material. And he rejected items if they were not what he had requested. His tutor, Harvard University's Irene Pepperberg, believes his cognitive skills were comparable to those of a 5-year-old child.

BETTY THE NEW CALEDONIAN CROW

SPECIAL SKILL: Making and using tools

Betty amazed scientists at the University of Oxford by fashioning a hook from a straight piece of wire to retrieve food at the base of a vertical glass tube. It was the first time a non-human animal had been observed making a new tool for a specific task without a model to emulate or learning by trial and error, indicating a good understanding of cause and effect.

AWISA THE AFRICAN GREY PARROT

SPECIAL SKILL: Logical reasoning

Seven African grey parrots watched a researcher at the University of Vienna in Austria hide a seed under one opaque cup and a walnut under another. Working behind a screen, the researcher then removed one of the snacks and showed it to the birds. Only one parrot, Awisa, was able to deduce which cup still contained food, indicating that she is capable of inference by exclusion.

RAVENS

SPECIAL SKILL: Gestural communication

Ravens use their beaks and wings to make gestures, such as pointing at an object of mutual interest to initiate a relationship with another raven. Great apes are the only other non-human animals known to use referential gestures, considered a precursor to language.

MAGPIES

SPECIAL SKILL: Self-recognition

Self-recognition is often seen as a hallmark of advanced cognitive abilities. Bottlenose dolphins, Asian elephants and some great apes can recognise themselves in a mirror. So can magpies, suggesting that this skill has evolved independently in different lineages.



responded more vigorously to imitations of their calls than to the drongos' own alarm calls. Similarly, a feathery blitzkrieg ensues when the greenish warbler imitates the mobbing call of the buff-barred warbler, and there is far less mayhem when it uses its own alarm call.

So it appears that mimics can trick other species into helping them mob an attacker – and that could be the difference between life and death. “It’s likely to be a safety-in-numbers thing,” says Branislav Igic at the University of Akron in Ohio. “The more prey there are flying around, the less likely the predator is to single you out. Mobbing also produces a lot of sound and movement, and that may confuse the predator.”

Some imitators even tailor their copycat alarm calls to particular threats. When Igic confronted brown thornbills with a taxidermy owl placed on the ground, they made calls produced by other bird species in response to terrestrial threats such as snakes or perched avian predators. When confronted by a gliding fibreglass sparrowhawk, however, these diminutive songbirds mimicked aerial-specific alarm calls. Intriguingly, they also produce these calls when disturbed in their nests by humans or captured in mist nests. Because there is no actual aerial threat in these cases, Igic suspects that this may be an attempt to deceive the assailant. “They might trick terrestrial predators into thinking there is a flying predator around, and in doing so deter the predator from the nest,” he says.

For now, the idea remains untested. But there is no doubt that some birds do use mimicry to deceive. Consider the cuckoo, a renowned parasite that disguises its eggs to trick a host species into raising them as its own. In Australia, Horsefield’s bronze cuckoo chicks take this deception a step further by impersonating calls made by nestlings of its primary host, the superb fairy wren. The chicks are born with this ability, a trait selected by evolution over countless generations.

Amazingly, though, when Naomi Langmore at the Australian National University in Canberra

transferred chicks into nests of the buff-rumped thornbill, they gradually adjusted their calls to match those of their new hosts’ nestlings. It seems that Horsefield’s bronze cuckoo chicks can fine-tune their impersonations through trial and error to arrive at a call that elicits the greatest response from at least two different host species.

Perhaps the craftiest of all avian impressionists, however, is the fork-tailed drongo. “They’re demonic-looking birds with beady red eyes and hooked beaks,” says Tom Flower at the University of Cape Town, who has spent years tracking wild drongos in South Africa’s Kalahari desert. They are very gregarious, associating with meerkats and southern pied babblers, and often warning their allies of approaching predators. But they are also excellent impressionists, and will gladly trick their allies in order to steal food.

Flower used playback experiments to show that the drongos’ impressions of alarm calls made by another local bird, the cape glossy starling, successfully trick babblers and meerkats. Even if there was no predator to be seen, animals of both species fled the scene when they heard the faked calls. It’s a very successful strategy: these drongos get about a quarter of their food by tricking their neighbours. It might seem as if the meerkats

“Using vocal mimicry for deception could be a sign that the mimic knows what other birds are thinking”

TOM FLOWER



Female satin bowerbirds are suckers for a good mimic (far left). The greenish warbler (left) imitates alarm calls to recruit help



Fork-tailed drongos (left) cry “hawk”, then steal food from other birds and meerkats



and babblers are easily duped, but it makes sense to pay attention to the drongos' alarm calls. After all, they only lose a meal by responding to a false alarm, but if they ignore a genuine warning, they pay with their lives.

They will stop reacting, however, if the drongos cry “hawk” too often. When Flower played the same type of alarm call three times in succession, he found that babblers were slower to flee. However, it seems the drongos are wise to this. Over the course of hundreds of hours of following them, Flower noticed something: “When targets stopped responding to one type of alarm call, they switched their calls,” he says. To find out whether this was a deliberate strategy, he recorded drongo calls on 151 separate occasions during which they made repeated attempts to steal food from the same individual. He found that drongos almost always swapped their alarms, especially after failed attempts – a ploy that increased their chances of stealing a snack.

“If drongos can attend to what their targets are doing and then change their tactics accordingly, it suggests they’re extremely flexible in their deceptive behaviour,” says Flower. So, how clever are they?

It has even been suggested that using vocal mimicry for tactical deception indicates that the mimic understands what’s going on inside

the minds of its targets. This ability is called theory of mind, and is often thought to be unique to humans. The idea that birds have it might sound like a stretch. But in the past decade, certain birds have proved to be far more intelligent than you might think (see “Who’s a clever bird?”, left). These include western scrub jays, which apparently understand what their peers are thinking.

Not so bird-brained

Scrub jays like to stash their food, hiding tasty morsels out of sight of fellow jays that might try to steal them. Nicky Clayton at the University of Cambridge and Nathan Emery, now at Queen Mary University of London, found that if a bird was observed cacheing food by another, it would privately find a new hiding place later. Such re-cacheing did not happen in the absence of an observer and was confined to birds that had been thieves in the past. That led Emery and Clayton to argue that this behaviour relies on a form of mental attribution: simulating the point of view of a potential thief. “That’s the strongest evidence for theory of mind in any [non-human] animal, bird or otherwise,” says Clayton.

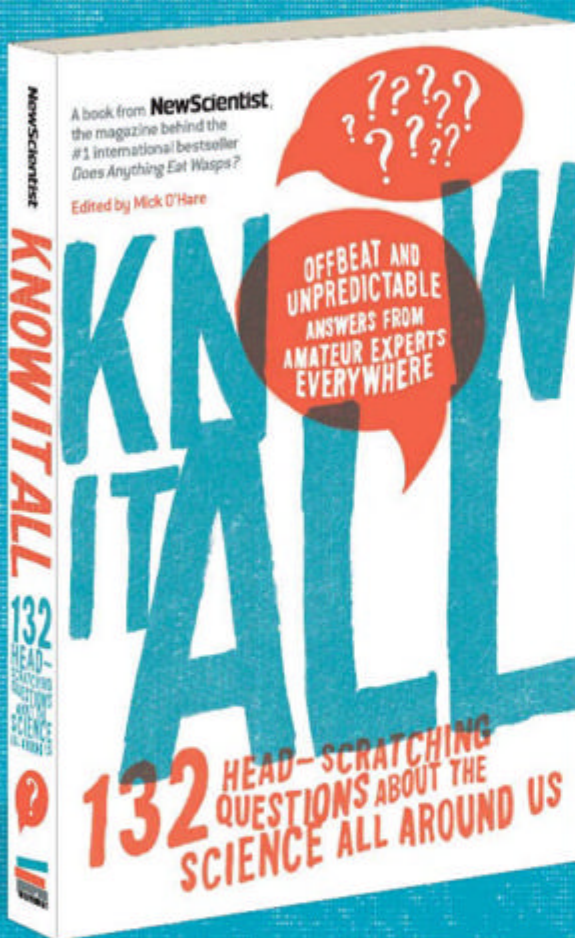
Are fork-tailed drongos equally intelligent? They are potential candidates, says Clayton. “If you’re looking for a place to find theory

of mind, you would start with big-brained animals that seem to exist in an ecology where this ability would be advantageous. But first you would need to rule out simpler explanations.” Indeed, Flower has his doubts. “In humans, this sort of behaviour requires very sophisticated cognition, but that’s not necessarily the case for a drongo,” he says. “My impression is that they’re likely to be trial-and-error learners.” He suspects they follow simple rules that amount to a “win-stay, lose-shift” strategy. But he is no killjoy: “Actually, I think it’s amazing what these birds can accomplish in terms of complex behaviour with such a simple mechanism.”

Either way, the debate about whether avian mimicry can increase a bird’s evolutionary fitness is over. Birds can undoubtedly benefit from their impersonations. The challenge now is to figure out how they evolved the mechanisms that allow them to do so. “What we’re trying to do is show why particular mechanisms are selectively advantageous; why it pays for drongos to use trial-and-error learning and why humans use theory of mind, for example,” says Flower. If they can answer those sorts of questions, then understanding mimicry could even help unlock the mysteries of how thinking evolved. ■

Daniel Cossins is based in London

THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . . KNOW IT ALL



The latest book in *New Scientist* magazine's bestselling "Last Word" series presents 132 science questions and answers from amateur experts and curious minds everywhere. Find the answers to the **microscopic** (*Why do sand particles on a beach seem to reach a certain grain size and then reduce no further?*), the **puzzling** (*How did the Romans express fractions?*), the **hypothetical** (*If humans lived in a zero gravity space station away from the sun, would skin still wrinkle and sag?*), and the **practical** (*What's the best strategy for getting through multi-lane traffic jams as quickly as possible?*)—any topic is fair game!

KNOW IT ALL: 132 Head-Scratching Questions About the Science All Around Us
\$14.95 • Available in trade paperback and as an ebook wherever books are sold

A GUARDIAN TOP 10 SCIENCE AND TECHNOLOGY BOOK

"The experts at *New Scientist* magazine have published a book that answers some of the oddest but most entertaining questions they've been asked."

—DAILY MAIL

"Explain[s] some of life's great mysteries."

—REVEAL

NewScientist



@experimentbooks
theexperimentpublishing.com

ALSO AVAILABLE
Nothing: Surprising Insights Everywhere from Zero to Oblivion
\$14.95 • Available in trade paperback and as an ebook wherever books are sold



Speaking in one voice

English is the universal language of science now. It wasn't always thus, finds **Mark Viney**

Scientific Babel: The language of science from the fall of Latin to the rise of English by Michael Gordin, Profile Books, £25



THE evening was warm, the beer was cold, and it was time to catch up. It was the last night of a scientific meeting and I spied three

friends: Marie-Anne, whose lab is in Paris; Christian, who's Swiss but works in Nice; and Thomas (also Swiss), based in Vienna. They were speaking French – the shoulder shrugs gave it away – but they are fluent in German too. As I joined them, they switched seamlessly to English. Well, of course: I'm British, so I only have a smattering of appalling French and German. But they also switched because English is the language of science.

It wasn't always thus. Replay the scene 150 years earlier, and we would all have been able to communicate in the triumvirate of German, French and English, at least. A few centuries earlier, and it would have been Latin.

Michael Gordin's excellent *Scientific Babel* asks what drives the languages science uses, and how English came to dominate. As he writes, "scientific languages are not born, they are made, and made with a good deal of effort". Gordin uses chemistry to guide our tour because this was the key science during the transition to monolingualism. His story is insightful, engaging and based on superb scholarship, lightly worn.

What a lot of trouble language has caused. For example, after Dmitri Mendeleev first published a table in Russian showing the relationships of the then known elements, he realised he needed to tell a wider audience. So he wrote a short summary, translated into German for *Zeitschrift für Chemie*.

Mendeleev discovered that the elements were periodic, but this was translated as *stufenweise*, or "phased". It was the repeating feature of periodicity that was Mendeleev's key insight. Reading the mistranslation, Mendeleev's rival, Julius Lothar Meyer, who had also noticed the periodicity, thought the use of the word "phased" meant that he could therefore claim the discovery of periodicity. In the best tradition of science, an argument ensued. At its nub was that Mendeleev's first papers were in Russian, which

"We may revert to a modern triumvirate of Chinese, English and Spanish/Portuguese"

Meyer could not read. As Gordin says, "to count as a significant language of science, it was not enough... to be written in, others had to be persuaded to read it".

It is the tension between mother tongue and a single language that has pulled and pushed at the languages of science. For example, as science uses a language, words diverge from their everyday meanings – take "compound" or "potential". This divergence drives a positive feedback loop: as a word in language A acquires a scientific



ULF BORJESSON/PLAINPICTURE/MASKOT

Communicating science is tough without a common language

meaning, that makes it more likely that that word (still in language A) will be used.

The babel of languages used in science by the late 19th century was a good argument for a "universal, ideally neutral" language, writes Gordin. The first candidate was *Volapük*, or "worldspeak". Then came Esperanto and Ido. These were popular, but crashed with the first world war. Worse followed.

Germany's post-war penalty was severe: exclusion from a globalising science, with many conferences off limits. This led to the inevitable decline of German in science. The second world war accelerated this both by leaching scientists from Nazi Germany, largely to the Anglophone US, and by post-war restructuring.

With German increasingly forced out of the triumvirate, that left French and English. As English overtook German during both world wars, French was squeezed

out. And as the "Fe Curtain" (a droll chapter heading) divided Europe, using Russian for science became politically important. Translating Russian into English was vital, so the West could see "what 'Ivan' was up to". This focus on the English of the West versus the Russian of the East only squeezed French still further.

But geopolitics doesn't entirely account for the hegemony of English. Nor, says Gordin, was there anything innately superior about the language. In fact, there is no one reason for its domination.

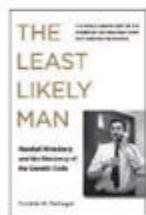
Will the dominance of English continue? We may revert from today's monolingualism (as with Latin) to multiple languages, perhaps a modern triumvirate of Chinese, English and Spanish/Portuguese, as new world orders evolve. Meanwhile, we lucky native English speakers should remember that for everyone else, their scientific working language is no mother to them at all. ■

Mark Viney is professor of zoology at the University of Bristol

DNA's forgotten hero

It's time to savour a little known story at the heart of genetics, says **Matthew Cobb**

The Least Likely Man: Marshall Nirenberg and the discovery of the genetic code by Franklin H. Portugal, MIT Press, \$27.95/£19.95



IN 1968, Marshall Nirenberg jointly won the Nobel prize in physiology or medicine for his decisive contribution to cracking the genetic code. Eight years earlier, Nirenberg and biochemist Heinrich Matthaei had used an artificial string of RNA featuring only the base uracil (U) to make the amino acid phenylalanine. The first word in the genetic code had been read: UUU codes for phenylalanine.

The way the discovery emerged is the stuff of legend. In August 1961, at the International Congress of Biochemistry in Moscow, Russia, the little-known Nirenberg gave a talk to a couple of dozen delegates, who were amazed. Word spread. The next day, Francis Crick rejigged the schedule to allow Nirenberg to speak to hundreds of leading researchers. The audience, says Crick, was “electrified”.

In one bombshell experiment, Nirenberg and Matthaei had shown the world how to crack the code. Over the following six years, Nirenberg played a key role in identifying the function of all 64 three-letter words, or codons, in our DNA.

In this first biography of Nirenberg, Franklin Portugal, who worked in his lab, tries to unravel how the man went from being an average student studying caddis

flies to a molecular biologist taking on such greats as Crick, Sydney Brenner and James Watson, and beating them at their own game.

Science historians are wary of “great men” explanations, whereas scientists writing history tend to revel in individuals. With Nirenberg, the two converge: he may have been in the right place at the right time, but he also had a unique insight into how to crack the genetic code.

This crucial discovery opened the floodgates: within a few months, Crick had demonstrated

that each codon had three letters. But Nirenberg was nearly swept away by the flood, as biochemist Severo Ochoa in New York moved into the field and rapidly churned out papers, some of which did not even cite Nirenberg and Matthaei.

Nirenberg had the last laugh. He worked out complex biochemical procedures for identifying the exact nature of the RNA codons that the cell uses to

introduce a particular amino acid into a protein, and Ochoa's lab eventually bowed out of the race.

Portugal's slim biography understandably concentrates on the years 1958 to 1967, using a unique legacy: dozens of lab diaries. In these, Nirenberg recorded ideas for experiments and jotted down exhortations to himself to work harder, and to his experiments simply to work.

Some of the diaries were cited by leading historian Lily Kay in her book *Who Wrote the Book of Life?* Portugal's selection overlaps Kay's, but neither satisfactorily explains why Nirenberg became fascinated by genetic code, nor what it was in his intellect and training that let him see a solution so many others missed.

In one of the book's other threads, Portugal claims that Crick ignored Nirenberg's alleged primacy in discovering messenger RNA, and effectively bullied him into sharing unpublished data.

In fact, Crick was extremely generous to the brilliant outsider. For example, he devoted the whole of a 1962 BBC lecture to Nirenberg. And he ended a *Scientific American* article in March of that year thus: “We are coming to the end of an era in molecular biology. If the DNA structure was the end of the beginning, the discovery of Nirenberg and Matthaei is the beginning of the end.”

Whatever the case, Nirenberg's brilliant contribution deserves to be more widely known. Portugal's fascinating book can only help. ■

Marshall Nirenberg came from nowhere to win a key scientific race



FRITZ GORDON/LIFE PICTURE COLLECTION/GETTY IMAGES

Matthew Cobb's book *Life's Greatest Secret: The race to crack the genetic code* is published next month

LET YOUR LOVE LIFE LIFT OFF — ON — NEW SCIENTIST CONNECT



We all know it's not rocket science trying to find that special someone with whom we connect, even though it sometimes feels that way. Which is why we've launched New Scientist Connect.

Meet like-minded people who share similar interests to you - whether you're looking for love, or just to meet someone on the same wavelength, no matter where you are in the world.

Launch your search now at: <http://dating.newscientist.com>



The University of Texas at San Antonio

Robert A. Welch Endowed Chairs in Chemistry at The University of Texas at San Antonio

The Department of Chemistry at The University of Texas at San Antonio (UTSA) seeks internationally renowned scientists to fill two newly established Robert A. Welch Endowed Chairs in Chemistry. The research area of one Chair is expected to encompass the interface of chemistry and biology. The research area of the other Chair can encompass any area of modern chemistry. Each Welch Chair includes a generous endowment, a highly competitive salary, and ample modern research space. Significant additional financial resources and state-of-the-art facilities are available. The scientists occupying these Welch Chairs are expected to play leadership roles in ongoing departmental growth and faculty recruitment. Opportunities are available for collaborative initiatives at UTSA and with nationally renowned area institutions, including the University of Texas Health Science Center at San Antonio and the Southwest Research Institute.

San Antonio is the 7th largest city in the U.S. and features a historical and vibrant downtown area. UTSA is located northwest of downtown San Antonio adjacent to the scenic Texas Hill Country, which provides many recreational opportunities.

Nominations and inquiries can be sent to the Department Chair, Dr. Waldemar Gorski, at the following address: Department of Chemistry, UTSA, One UTSA Circle, San Antonio, TX 78249 or via email (Waldemar.Gorski@utsa.edu).



Wake Forest®
School of Medicine



A Mission to Care. A Mission to Cure.

Cancer Research is a priority at Wake Forest Baptist School of Medicine and our NCI-designated Comprehensive Cancer Center, located in Winston-Salem, NC. We are proud to be among the elite group of cancer centers acknowledged as the nation's leaders in the fight against cancer. The Wake Forest Institute for Regenerative Medicine (WFIRM), a world class research program in the development of regenerative and stem cell therapies, the Sticht Center on Aging, the Center for Human Genomics, and other research entities provide a dynamic environment for cutting edge multidisciplinary research.

We have opportunities in: Cancer Biology, Cancer Prevention & Control, Cancer Genomics, Cancer Biochemistry and more.

For more information visit www.wakehealth.edu or contact mkiger@wakehealth.edu

Director, NASA Astrobiology Institute

NASA seeks a new Director for the NASA Astrobiology Institute (NAI). The ideal candidate will be an internationally recognized scientist with proven experience in leading or managing large interdisciplinary research programs or projects, possessed with a vision for leading the Institute into the future.

Applicants for this position should have a broad scientific perspective on astrobiology, experience in conducting interdisciplinary scientific research, and demonstrated skills needed to harness the strengths of disparate research communities towards a greater goal. S/he should understand how to grow a research endeavor and respond to changing budget climates while focusing on maximizing the scientific return on NASA's investments in astrobiology. S/he should have experience in leading a diverse staff ranging from established scientists to support personnel, resource planning, and executing budgets and schedules. S/he should be comfortable with modern information technologies and distributed research teams. NASA is particularly interested in applicants who will find ways to infuse astrobiology into NASA flight missions.

Interested individuals should apply directly to USAJobs at www.usajobs.gov

by May 1, 2015.

In the keyword search box, type vacancy number "AR15S0001". Select "Director, NASA Astrobiology Institute", then click "Apply Online".



Knowledge that will change your world

The University of Alabama at Birmingham

GYNECOLOGICAL CANCER RESEARCH POSITION Department of Pathology

The Department of Pathology at the University of Alabama at Birmingham (UAB), in collaboration with the UAB Comprehensive Cancer Center, is committed to building an active research program in the area of gynecological cancer. We are therefore inviting applications for a tenured or tenure-track faculty position at the Associate or Full Professor level from scientists (Ph.D., M.D., M.D./Ph.D.) depending on experience, research and scholarly accomplishments. Applicants should have an actively funded research program in the area of gynecological malignancies. Successful candidates will have a demonstrated record of originality and productivity in research with existing NIH funding as well as a commitment to graduate education in cancer biology. Exceptional candidates will be eligible for appointment to the Hazel Gore, M.D., Endowed Professorship in Gynecologic Pathology. UAB, which ranks in the top 25 in NIH funding, is a dynamic, collaborative research institution with state-of-the-art facilities, excellent graduate programs, and a commitment to post-doctoral education. Faculty will be expected to participate in the training of graduate students. The candidate will be appointed as a member of the Division of Molecular and Cellular Pathology in the Department of Pathology. A pre-employment background investigation is performed on candidates selected for employment. Interested candidates should submit a cover letter that includes research interest/experience, a curriculum vitae, and the names of three references to: Ralph Sanderson, Ph.D., Chair of Search Committee, Professor, Division of Molecular and Cellular Pathology, Department of Pathology, email PATH-MCPFRecruit@mail.ad.uab.edu

UAB is an Equal Opportunity/Affirmative Action Employer committed to fostering a diverse, equitable and family-friendly environment in which all faculty and staff can excel and achieve work/life balance irrespective of race, national origin, age, genetic or family medical history, gender, faith, gender identity and expression as well as sexual orientation. UAB also encourages applications from individuals with disabilities and veterans.

The Association for Women in Science

Smart Women Doing Cool Stuff

Join our community of over 20,000 women and men working in STEM fields.



Visit www.awis.org and join today.

AWIS

Biodomain Researcher



Purpose

Candidates are sought to fill a scientist position in Shell's Biofuels Research and Development program. The program is focused on delivering Next Generation Biofuels into the market, primarily from ligno-cellulosic feedstocks, by both biological and thermochemical routes.

Role Accountabilities

The role will be based in Shell's Projects & Technology Group, located in the Shell Technology Center, Houston, Texas. The successful candidate will work within Shell's in-house Microbial Biofuels team, scaling-up Shell's proprietary ligno-cellulosic biofuel process from the bench to production scale. The challenges in such a process range from soil carbon and ecosystem services analysis, through enzyme hydrolysis, solid and liquid phase fermentation, to molecular microbiological transformations.

Potential candidates will be engaged in a range of activities such as: ecosystem service modelling, molecular transformation, microbial pathway evolution, enzyme hydrolysis, novel fermentation, and organism research.

Responsibilities will include: design and implementation of experimental programs aimed at producing commercially viable biofuels from micro-organisms, taking into account a wide range of contributory factors; and identifying opportunities and engaging with the development of commercial plans.

Candidates are expected to have excellent intellectual and analytical ability, the enthusiasm to progress their insights, strong teamwork and leadership skills, as well as the ability to broaden outside of their area of expertise. The successful candidate will be expected to work with Shell engineers globally, as well as with external partners.

Required Qualifications/Skills

Ideally, the successful candidate will have a PhD (or be in their final year/ write-up of a PhD) in one of the following areas, or a related field:

- Microbiology
- Biochemistry
- Environmental Microbiology

They will have demonstrated a willingness to learn and apply cross-discipline approaches to solving problems, and be happy working in a tight-knit team.

Experience in one or more of the following areas would be a distinct advantage:

- Soil carbon pathways and sequestration
- Metabolic pathway improvement via transformation
- Enzyme hydrolysis
- Solid or liquid fermentation (batch or continuous flow at pilot scale)

Application Requirements

- To be eligible for Graduate full-time opportunities, you should be in your final year of study or have less than three years of work experience.
- You must have a minimum Cumulative GPA (CGPA) of 3.20.
- Candidates for regular U.S. positions must be a U.S. citizen or national, an alien admitted as permanent resident, refugee, asylee, temporary resident, or an individual who possesses valid work authorization. Individuals with temporary visas (H-1, H-2, J-1, F-1, etc.) or who require sponsorship for work authorization now or in the future are not eligible for hire.

How to Apply

- In order to be considered for this position you must apply online at www.shell.us/careers.
- In the "Students and Graduates" section, click on "Shell Recruitment Day" and then create an account. When entering your contact details, select "Other" in response to "Where you found out about this Shell opportunity," click "Next" and then type in "Biodomain Researcher."
- We require a completed application, an updated copy of your résumé and an unofficial copy of your transcripts / grade report prior to be considered for an interview.



Knowledge that will change your world

The University of Alabama at Birmingham

DIRECTOR, DIVISION OF INFORMATICS Department of Pathology

The University of Alabama at Birmingham (UAB) Department of Pathology is seeking an outstanding candidate at the **tenure/tenure-earning Associate Professor or Full Professor** level with experience in the field of biomedical informatics to lead its Division of Informatics. Extensive experience in biomedical informatics, or bioinformatics/computational biology and a **M.D. or a Ph.D.** in a related professional field is required. Candidates must have a demonstrated expertise in one of the areas of biomedical informatics and the ability to retain extramural funding. He/she will work across departments, centers and schools to enhance medical informatics, public health informatics and bioinformatics at UAB.

Four years ago, the UAB School of Medicine committed significant resources to the establishment of a Division of Informatics in the Department of Pathology and the implementation of a campus-wide clinical informatics infrastructure. During that time the division grew to five faculty, hosting multiple informatics resources in sequence and image analysis, and offering a suite of well attended immersive courses in Biomedical Informatics and Computational Pathology for both medical and graduate trainees. The new Director will be expected to continue the expansion of the Division through additional recruitment and new investments that further advance its research, education and service portfolio. The Director will participate in the development of two new Institutes at UAB, Informatics and Personalized Medicine.

The UAB-School of Medicine is located in Birmingham, AL and is ranked 26th in NIH funding. The UAB Health System is a >\$2 billion/year enterprise, consisting of University Hospital (981 beds; with installed Cerner enterprise software), The Kirklin Clinic (1,100 physician group practice), VIVA Health (a regional HMO), UAB Highlands Hospital (specialty hospital), Prime Care (primary care network), and affiliated hospitals in Montgomery and Bessemer. UAB has established high performance computing and high speed connectivity to the Lambda Rail, as well as supports the Alabama Supercomputer Facility in Huntsville, AL. The UAB Comprehensive Cancer Center, together with its partner HudsonAlpha Genomics Research Institute in Huntsville, is a key participant in The Cancer Genome Atlas.

The position offers an excellent and comprehensive compensation and benefits package. All inquiries should be directed to: **Kevin A. Roth, M.D., Ph.D., Robert and Ruth Anderson Professor and Chair, Department of Pathology, UAB, 619 South 19th Street, WP 210, Birmingham, AL 35233-7331 email: path-informdir@mail.ad.uab.edu**. Interested applicants should submit: 1) a cover letter; 2) curriculum vitae with the names of three references; and 3) a statement of research interests.

Evaluation of applications will occur as they are received and will continue until the position is filled. A Pre-employment background investigation is performed on candidates selected for employment. In addition, physicians and other clinical faculty candidates who will be employed by the University of Alabama Health Services Foundation (UAHSF) or other UAB Medicine entities must successfully complete a pre-employment drug and nicotine screen to be hired.

UAB is an Equal Opportunity/Affirmative Action Employer committed to fostering a diverse, equitable and family-friendly environment in which all faculty and staff can excel and achieve work/life balance irrespective of: race, national origin, age, genetic or family medical history, gender, faith, gender identity and expression as well as sexual orientation. UAB also encourages applications from individuals with disabilities and veterans.



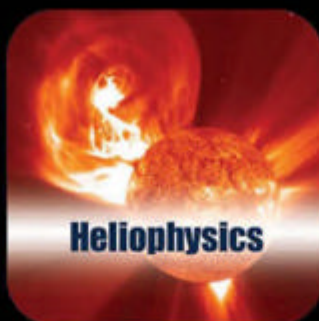
NASA

Postdoctoral Program

administered by Oak Ridge Associated Universities



Earth Science



Heliophysics



Astrophysics



Planetary Science



Astrobiology



Space Bioscience



**Aeronautics &
Engineering**



**Human Exploration
& Operations**



Space Technology

The NASA Postdoctoral Program (NPP) supports NASA's goal to expand scientific understanding of Earth and the universe in which we live.



The NASA Postdoctoral Program offers U.S. and international scientists the opportunity to advance their research while contributing to NASA's scientific goals. The NPP supports fundamental science; explores the undiscovered; promotes intellectual growth; and encourages scientific connections.

Details

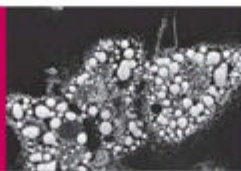
- Annual stipends start at \$53,500, with supplements for high cost-of-living areas and certain degree fields
- Annual travel budget of \$8,000
- Relocation allowance
- Financial supplement for health insurance purchased through the program
- Appointments renewable for up to three years
- Approximately 90 Fellowships awarded annually

Application Deadlines

Three each year - March 1, July 1, and November 1

Apply at <http://nasa.orau.org/postdoc>

Be the force behind the cures.



PERFORM IMPORTANT RESEARCH ON A TEAM THAT NEVER QUILTS.

EOE/Minorities/Females/Vet/Disability
©2014 St. Jude Children's Research Hospital-Biomedical Communications.

Internationally recognized as one of the premier centers for groundbreaking pediatric research, St. Jude Children's Research Hospital offers an outstanding opportunity to do cutting-edge work with world-renowned scientists.

Efforts are directed at understanding the molecular, genetic and chemical bases of catastrophic diseases in children. Using the state-of-the-art shared resources available at St. Jude, scientists do exceptional research and generate high-quality data leading to discovery.

We are recruiting for research positions throughout the institution with opportunity for advancement within our research career ladder.

To learn more, visit www.FindStJude.jobs and enter code: **NewScientist**



Technical/Research Assistants

The Koch Institute for Integrative Cancer Research, a National Cancer Institute (NCI)-designated Cancer Center, is a state-of-the-art cancer research facility as well as the hub of cancer research on the MIT campus. The Koch Institute (KI) brings together biologists and chemists along with biological, chemical, mechanical, and materials science engineers, computer scientists, clinicians and others, to bring fresh perspectives and an interdisciplinary approach to advancing the fight against cancer. This multi-faceted group of investigators is at the core of the Koch Institute's mission to develop new insights into cancer, as well as new tools and technologies to better treat, diagnose and prevent the disease.

The KI has several exciting Technical/Research Assistant positions open now and in the coming months. These positions are critical to our mission, supporting and enhancing cutting-edge, interdisciplinary, cancer-focused scientific/engineering projects. We are looking for individuals who value creativity, diversity, inclusion, and collaboration. Why not be part of a supportive community that fosters personal and professional development? Once you're here, you'll want to stay.

As a Technical Assistant, you will be part of a dynamic team and will provide technical expertise and support by: organizing and completing experiments and tests by studying project objectives and processes; documenting results; keeping project leader informed; maintaining equipment; maintaining and a safe and healthy work environment; completing experiments and tests; performing protocols; updating job knowledge; exploring opportunities to add value to job accomplishments.

Minimum Qualifications: BS in Biological Sciences or other relevant field; hands-on experience in research laboratory environment; experience informing superiors and peers based on their information needs; committed to exceeding quality standards and providing exceptional services; exhibits meticulous attention to detail; committed to producing accurate and high-quality work; practiced documentation skills; uses multiple resources, quantitative, and qualitative research methodologies to capture and interpret information; aware of basic safety issues; follows safety procedures and maintains a safe work environment; trained in hands-on equipment maintenance.

MIT is an equal employment opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, religion, sex, sexual orientation, gender identity, national origin, veteran status, or disability.

Apply online at careers.mit.edu, search for keyword "Koch."



THE UNIVERSITY OF ALABAMA AT BIRMINGHAM



Postdoctoral Positions

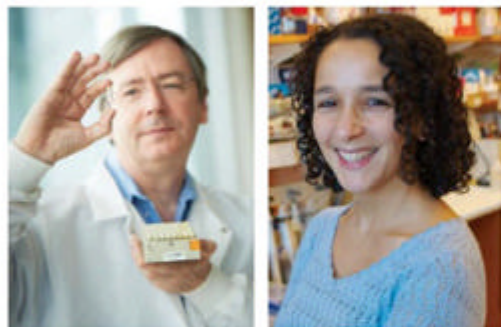
The University of Alabama at Birmingham (UAB) is one of the premier research universities in the US with internationally recognized programs in AIDS & bacterial pathogenesis, bone biology & disease, cancer, diabetes & digestive & kidney diseases, free radical biology, immunology, lung disease, neuroscience, trauma & inflammation, and basic & clinical vision science among others. UAB is committed to the development of outstanding postdoctoral scientists and has been consistently ranked in recent years as one of the top locations among US universities for training postdoctoral scholars.

UAB is recruiting candidates for postdoctoral positions in a variety of research areas. UAB faculty are well funded (top 25 in NIH funding), utilize multidisciplinary approaches, and provide excellent research training environments that can lead exceptional candidates to entry level positions in academia, government or the private sector. Full medical coverage (single or family), competitive salaries/stipends, sick leave, vacation, and maternity/paternity leave are offered with every position as well as AD&D, disability & life insurance. Depending on the source of funding, retirement benefits may also be available. Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities and a cost of living rate lower than most metropolitan areas.

Visit our website at www.uab.edu/postdocs/openings, to view positions. See info also on MERIT Program, an NIH IRACDA program. Send your CV to the contact name for the positions that you are interested. University of Alabama at Birmingham, Office of Postdoctoral Education, 205-975-7020.

UAB is an equal employment opportunity employer.

We're Curing Childhood Cancer. *Won't You Join Us?*



To view all CCCR career opportunities,
including several open post-doc fellowships,
visit chop.edu/careers.

At the Center for Childhood Cancer Research (CCCR) at The Children's Hospital of Philadelphia, we have over 85 affiliated scientists with 56,000 square feet of research space and access to one of the largest, highest-ranked clinical programs for pediatric cancer in the nation.

Our fully-integrated clinical, translational and basic science research program spans the entire spectrum of pediatric oncology. We sponsor a wide range of clinical trials, including a large and growing portfolio of investigational therapies for patients with refractory cancers. Our pioneering work in immunotherapy is making headlines — and there is so much more to come.

The Center for Childhood Cancer Research offers unmatched opportunities to bring tomorrow's advancements to children today — while honing your skills for the future.

EDITOR'S PICK



Science involves belief but not faith

From Kate Szell

I was intrigued by your claim that science is not a belief system (4 April, p 5). Surely what it is not is a faith system. Science is belief based on evidence: faith, on the other hand, is belief irrespective of evidence.

Science gives rise to beliefs that fit the existing evidence, allowing for them to change should new evidence make that sensible.

Faith takes beliefs and puts them on an untouchable pedestal where they remain, no matter what contradictory evidence there is.

Most of us frequently employ a fairly scientific belief system. Take the simple example of the day of the week. When I woke up this morning, I believed it to be Thursday, based on the evidence of my memory. Had I then looked at my computer, my phone and a newspaper and seen the day given as Friday, I would have changed my belief, trusting the evidence of the computer, phone and newspaper over my memory. However, if I applied a faith-based belief system, I would have refused to take note of the contrary evidence and insisted that the day was Thursday, no matter what.

It is lack of faith, not lack of belief, that makes science so special and so wonderful.

London, UK

To read more letters, visit newscientist.com/letters

Voting for empathy or for negativity

From Darach Conneely

The article "We are what we vote" may have missed a disturbing aspect of populist politics (4 April, p 24). Brain scans appear to show very clear differences between psychopaths and people who feel empathy. But when normal people were led to believe that they were observing a person suffering and that this person was a cheat, or not part of "our tribe", their scans looked the same as those of the psychopaths, with no sign of any empathy: see, for example, "Dehumanizing the lowest of the low" by Lasana Harris and Susan Fiske (doi.org/dn7hpd).

The traditional strategies of populist politics appear to create the very distinctions that switch off our ability to feel empathy. When politicians and media call the unemployed and people with disabilities "benefit cheats" and "scroungers", does it turn off voters' ability to feel empathy for the members of society hit hardest by benefits "sanctions" and cutbacks?

Perhaps this might also explain one of the biggest riddles about populism. Why has it so often turned murderous in the past, and why can ordinary, decent, caring people be led into committing atrocities? Is it because it turns attitudes to outsiders psychopathic? *Llanelli, Carmarthenshire, UK*

From Peter Mendenhall

The negativity bias associated with voting may also explain why two-party politics in the UK has declined over several decades. The Politician's Dilemma, as I call it, is that negative campaigning is effective in the short term but counterproductive in the long term. When party A attacks party B, B has to retaliate to reduce support for A.

They would be predicted to each retain a higher share of the

votes if only they agreed not to attack. Each would, however, then be vulnerable to the other party "defecting" from the agreement by resuming attacks. So they never agree and both suffer. Each election forms the reference point for the next: so the vote total for the pair inexorably falls over many elections towards the tipping point at which other parties affect the outcome.

Nottingham, UK

Butterflies, causes and hurricanes

From Ian Stewart

Stuart Leslie's letter makes several correct statements about the butterfly effect (4 April). But it is more informative to understand the sense in which this metaphor is true, instead of demolishing one interpretation in which it is false. It is not true that events of the magnitude of a butterfly flapping its wings do not affect major events such as hurricanes. Indeed, weather forecasters have had to grapple with this problem since they became aware of chaos theory. Very tiny changes to the current state of the weather, put into the equations that predict future weather, lead to large-scale changes in the forecast.

The "butterfly effect" in this sense is what we mathematicians call "sensitive dependence on initial conditions". The physical laws that govern the weather are such that, if we could run the Earth's weather twice with the only initial difference being flap or no flap, the results would diverge exponentially.

Even though in reality there are innumerable "butterflies", each causes the end result to vary unpredictably. What one flap really causes is the difference between the two "runs", in the context of the rest of the weather system. A different flap, in this sense, might "cause" a tornado in the Philippines, compensated for

by snowstorms over Siberia. It is impossible in practice to cause a specific hurricane by employing suitably trained butterflies. Nevertheless, in other contexts, such as electrically nudging heartbeats, such "chaotic control" provides an efficient route to desired dynamic behaviour. *Coventry, West Midlands, UK*

From Tim Morrison

Leslie's letter on the butterfly effect also implies a question on the efficacy of those butterflies. If one assumes a billion butterflies (that's just 50,000 per species) flapping their little wings three times a second for a couple of hours a day during a hurricane season of 100 days, and all we see is 100 or so hurricanes and cyclones worth the mention, then that's 20 trillion wing flaps per achieved hurricane.

St Albans, Hertfordshire, UK

We believe these are not delusions

From Jon Arch

New Scientist has often presented arguments that free will is an illusion. So why is the belief that "your thoughts are not fully under your control" listed as a delusion (4 April, p 28)? Perhaps the deluded ones are the 66.4 per cent who believe that they have full control.

Paradoxically, my writing of this letter and the thoughts in it are not, at the deepest level, under my control, even if I sense that they are. But regular readers will know that both the workings of the mind and the nature of matter are riddled with paradoxes.

Welwyn Garden City, Hertfordshire, UK

From Gail Smith

I have delusion-like beliefs. If I were to be asked if I was in control of all of my actions, or all of my thoughts, I would answer "no". My argument would be that I am clearly not in control of my

f “If there’s one thing I look for in champagne it’s the taste of wet hair!”

Toby Hawkins on Facebook on a tasting of bubbly preserved undersea for 170 years (25 April, p 20)

actions – for example, when I respond to pain. I am not in control of my thoughts when worry keeps me awake at night...

This article as a whole makes a strong case for me not being fully in control of my thoughts, since these link into my belief system, over which I do not have conscious control.

I’m surprised that fewer than half the UK population hold these beliefs – or am I so delusional that I’m missing something here?
Neston, Cheshire, UK

From David Waltner-Toews

If your belief system is, even in part, the outcome of evolutionary forces, then it is not a delusion to believe that you are not fully in control of your thoughts.
Kitchener, Ontario, Canada

The Big One still hangs over us

From Ron Gibson

As a very old geologist, I could not agree more with Bill McGuire’s warning of the inevitability of

catastrophic volcanic eruptions (28 March, p 26). We in California face a similar catastrophic natural event – a great quake along the San Andreas fault.

In 1964, before the plate tectonics revolution led to understanding of large-scale movements in Earth’s crust, I presented a paper to a Geological Society of America conference making the case that a 10-million-year-old formation is offset by 80 miles across the San Andreas fault. I was laughed off the stage.

Conventional wisdom at the time simply could not accept such enormous displacements. It is now pretty apparent that the San Andreas fault should produce a great quake every 50 to 100 years. Our last one was in 1906 and since then two great cities have been built on top of the fault – a recipe for the greatest natural disaster in the history of the US.

Thousands will die, freeways collapse, utilities, water and food sources will disappear – it is going to happen. Only two questions remain: how soon, and will it be northern or southern California?
Irvine, California, US

From Martha Adams

McGuire both makes a point about the impact of disasters such as volcanic eruptions and misses the size of the question about human preparedness. In *The Collapse of Western Civilization*, historians of science Naomi Oreskes and Erik Conway, imagine “The Great Collapse of 2093”, caused by disintegration of the West Antarctic ice sheet. They write that “the most astounding fact is that the victims *knew what was happening and why*. Indeed, they chronicled it in detail precisely *because* they knew that fossil fuel consumption was to blame.” This is the process that McGuire is writing about.
Quincy, Massachusetts, US

Survival starting from when?

From Sylvie Yannello

A bar graph with your article on growing cancers compares five-year survival rates for a variety of cancers from the 1970s against those of the 2000s (28 March,

p 42). But since “five-year survival” starts from the date of diagnosis rather than the cancer’s inception, it reflects timing of detection as much as patient longevity. For instance, the 30 per cent increase in five-year survival for breast cancer may simply mean that cancers are being diagnosed earlier in their development, so even though patients survive longer after their initial diagnosis, they could be dying at the same stage in the progress of their disease as they did in the 1970s.

Long Island City, New York, US

Scepticism sours sexting statistic

From Ella Taylor-Smith

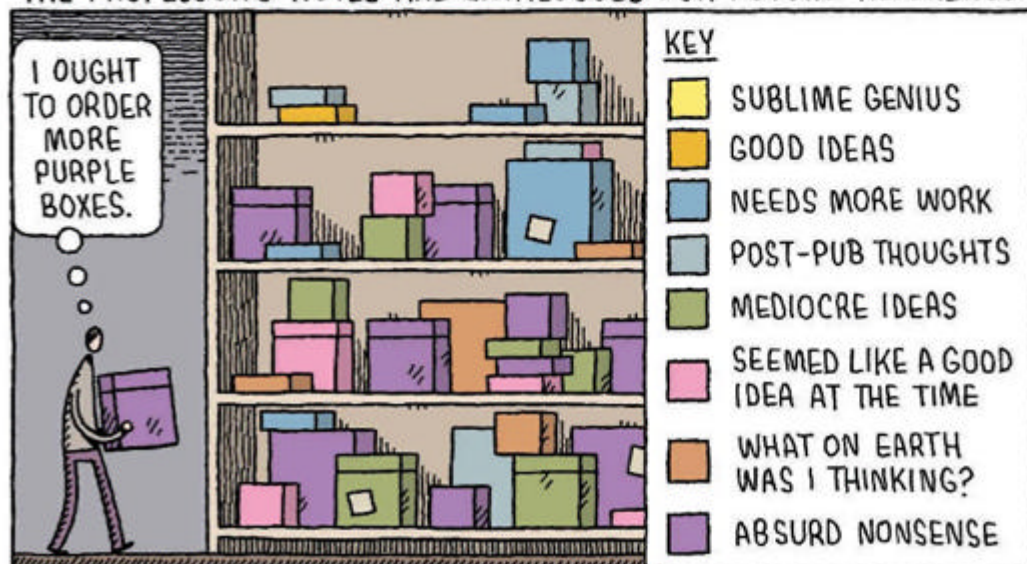
Douglas Heaven asserts that “sexting is as common among teens as texting a decade ago” (28 March, p 46). Really? I suspect that most teens are too sensible.
Edinburgh, UK

The editor writes:

■ Surveys report that about a third of US kids in their upper teens have sexted.

TOM GAULD

THE PROFESSOR’S NOTES ARE CATALOGUED FOR FUTURE REFERENCE



For the record

- We meant to write that the 103 gigawatts of electricity generating capacity added by renewables worldwide equals the capacity provided by nuclear power plant reactors in the US (4 April, p 7).
- We failed to react to an invasive meme. Macrophages are immune cells, not molecules (18 April, p 32).

Letters should be sent to:

Letters to the Editor, New Scientist,
110 High Holborn, London WC1V 6EU
Email: letters@newscientist.com

Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.



PAUL MCDEVITT

FEEDBACK recently mused on the significance of the recurring number 187.5 in the frequency distribution of fast radio bursts (18 April). Was it a message from the beyond? As the ink was drying on that question, more mundane news about radio bursts filtered out, in a paper from the Parkes radio telescope in New South Wales, Australia, posted at bit.ly/RadioBursts on 9 April. You will observe that Feedback's ink takes a while to dry.

The paper concludes that signals resembling cosmic radio bursts "can be generated at 1.4 GHz when a microwave oven door is opened prematurely and the telescope is at an appropriate relative angle". It shows an impressive correlation between some signals and local lunchtime.

Parkes people were impatient for their soup, in short. But the "fast radio bursts" in the original puzzle remain.

COSMIC numerology is still a thing, then. We reported Chris Conklin's thoughts about crystal oscillators being a possible source

of mysteriously-proportioned fast radio bursts (18 April). Since then Alan Wilson has thought about the possibility of a radio source moving away from us, or of space expanding between us and it. David King noted sceptically that "the beams were observed in completely different regions of the sky". Our mailbox fills with more suggestions as we write.

CHALLENGES to our understanding of the universe continue to arrive. Paul Segal sends an image that the Australian Broadcasting Corporation initially captioned "Scientists at the LHC celebrate after colliding protons at record power, mimicking conditions close to the Big Bang that created the universe in 2010." Proponents of the notion that the universe was created recently: Paul notes that nowadays "you can find them anywhere".

FEEDBACK's inbox is regularly graced with missives from

organisations under the name "Christian Concern". Last week they were angry about the biblical scholarship of Judge Shamim Ahmed Qureshi (25 April). This week they turn to attempts to forbid "conversion" – in the sense of "therapy" claiming to set gay people on the way of the straight.

Their way is, as King James's translators put it, "strait". They have therefore rebranded their campaign as one for the human rights of "young people facing unwanted same-sex attraction".

On first reading, that looks like a campaign to "protect" young people from others. We read it again, and it seems that Christian Concern wants to protect gay youngsters from themselves, but not to be clear about their archaic views, which shows that society has made progress of a sort.

WHAT could go wrong with an organisation such as "Christian Concern" sending regular messages to Feedback? Certainly, unexpected things. Even more unexpected, perhaps, than the things that can go wrong when people reach for metaphors for unexpected things.

David Smith notes our mention of Nassim Taleb's use of "black swans" (11 April). "Purveyors of this notion have probably never visited New Zealand or Australia," he writes, "where black swans are as common as muck and a white swan is simply not to be seen – well, probably not!"

Digging into the archive, we discover that, after an interview with Taleb (1 July 2006, p 50), Elizabeth Bromham noted that to her "a black swan is a joyous, and common, sign of a healthy ecosystem" (29 July 2006, p 22). So the unusual issue reoccurs...

THINKING of things going wrong, Chris Curnow is worried about the new design for the UK pound coin – announced coincidentally, no doubt, in the run-up to the election on 7 May. It has 12 sides. He provides the delightful information that "faceted" coins such as the existing seven-sided 50p coin, with each side an arc

centred on the opposite corner, are "Reuleaux polygons". The images of the new coins we have seen have straight sides. Is this a cunning plan to achieve the same effect as the "monetarist" policy of Ronald Reagan and Margaret Thatcher by reducing what economists call the "velocity of money" – or at least the part of the money supply whose shape may now cause it to become wedged in coin-operated machines?

FINALLY, we hear that no one uses voicemail any more. Explanations vary between experts: people are texting, using social media, or are annoyed by telemarketer messages.

But attempts to reach a professor at George Washington University in Washington DC reminded us of another reason – the voicemail systems themselves. The phone went unanswered after four rings. We were



switched to voicemail and a robotic voice asked for the mailbox number. We guessed this referred to the last four digits: the robotic voice said that was not a valid mailbox. We tried the last five digits and the phone started ringing. After four rings, it transferred to a robotic voice, which asked...

This is not the first infinite voicemail loop we have met. Does anybody ever notice that they are no longer getting voicemail?

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Over the emergency-exit window of a Cardiff bus, Mike Alcock finds a hammer behind glass labelled "For access strike here", and the warning: "Do not break glass with the hand." So with what?

Hisssssss

How long do I have to wait after dropping a beer bottle before I can safely present it to a guest, and how did its internal pressure build up if the system is in equilibrium?

■ The pressure inside a bottle of beer is unchanged after it has been dropped.

What has changed is the number of tiny bubbles that are distributed throughout the beer. These form when a bottle is dropped or shaken. When the bottle is opened, the bubbles act as nucleation points for the dissolved carbon dioxide, which comes out with such a rush that it takes a lot of the beer with it. This is a terrible waste: not only is good beer lost, but what remains is flat.

As the writer suggests, this doesn't happen if you wait before opening the bottle. How long you must wait depends on a number of things: the size of the bubbles, how deep in the liquid they are and the viscosity of the beer. To be

the bottle at the back of the refrigerator and take out another – with greater care.

*Andrew Carruthers
Quebec, Canada*

Angle of dangle



What are these (see photo, above)? There were about 20 creatures, some headless. They were found in Victoria State, Australia, about 10 kilometres from the coast at Ceduna.

■ These appear to be the cases of ribbed case moths, *Hyalarcta nigrescens*. The species seems relatively common throughout south-east Australia.

Case moths, sometimes known as bagworms, are primitive moths of the family Psychidae. The males of such moths have sparsely scaled wings, with transparent forewings and blue hindwings, as well as hairy bodies and combed antennae. The larvae feed on eucalyptus leaves.

In the instance pictured, the ribbed case is fashioned entirely from larval silk, but other species

usually construct their cases with grains of sand or plant debris.

For most case moths, the female is wingless and spends her entire life within the case. In order to mate she protrudes her abdomen from the mouth of the case and then emits a pheromone to attract the males.

Males can often be seen flying in daylight and can be followed to locate the female. Once mated, the females lay their eggs within the case.

The cases depicted here seem to have belonged to males. You can tell because we see the dark skin shed by pupae protruding from the mouth of the cases, the occupants having already squeezed their way out and departed.

*Terence Hollingworth
Blagnac, France*

■ Ceduna is in South Australia, not Victoria, and is just less than 1000 kilometres as a crow might fly from the nearest point on the Victorian border. I hope your correspondent made it back home to Queensland without getting lost.

*Peter Webb
Adelaide, South Australia*

in the chemistry of the oceans before the first fish evolved?

*Tom Curtis
London, UK*

COUNT THE DIMS

Presumably exoplanets can only be detected when the star they orbit dims as they pass in front of it as viewed from Earth. Have astronomers calculated what percentage of planetary systems meet this criteria? If so, how?

*Paul Lea
Exeter, Devon, UK*

"Is my 4-year-old whippet self-medicating, and if so, how does he know which plant to eat?"

MERLIN'S MAGIC

My dog, a 4-year-old whippet called Merlin, occasionally seems to select and eat goosegrass (*Galium aparine*) from a hedgerow, carefully pulling out stalks and ignoring the other plants surrounding it. Is he self-medicating, and if so, how does he know which plant to eat?

*Andy Maslen
Salisbury, Wiltshire, UK*

INSIDE OUT

What effect would the accelerated particles in the Large Hadron Collider have if they hit a human body? And what would happen if particles aimed at each other collided inside you, or collided with one of your own particles?

*Mick Johnson
Leeds, UK*

"When the bottle is opened the bubbles act as nucleation sites for dissolved carbon dioxide"

safe, one has to wait long enough for the last, smallest bubble to reach the surface and burst, before removing the cap.

In my experience about 10 minutes is normally enough. However, a 10-minute wait may be asking too much of a thirsty beer drinker, so it is far better to place

The writers of answers that are published in the magazine will receive a cheque for £25 (or US\$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

Reed Business Information Ltd reserves all rights to reuse all question and answer material that has been

submitted by readers in any medium or in any format and at any time in the future.

Send questions and answers to The Last Word, New Scientist, 110 High Holborn, London WC1V 6EU, UK, by email to lastword@news scientist.com or visit www.news scientist.com/topic/lastword (please include a postal address in order to receive payment for answers). Unanswered questions can also be found at this URL.

This week's questions

SHE SMELLS SEA SMELLS

Does the sea smell of fish or do fish smell of the sea? What is responsible for the characteristic seaside smell, and was it present

Question Everything

The latest book of science questions: unpredictable and entertaining. Expect the unexpected

Available from booksellers and at news scientist.com/questioneverything



Imagine
400,000
thinkers and
tinkerers
working for
your startup.



UPS for small business. Just because you're new doesn't mean you have to think small. We've got the tools, technology and a veritable army of experts ready to roll up their sleeves to help you with everything you need. Whether it's helping you get your product to market as quickly as possible or setting you up with online tools, such as UPS Quantum View®, to make it all run smoothly, we're here for whatever your business needs. From figuring it out to getting it done, we're here to help.
ups.com/solvers/gb

ups united problem solvers™



© 2015 United Parcel Service of America, Inc.